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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 BUDGET ESTIMATES

NASA'S VISION FOR THE FUTURE

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

NASA's unique mission of exploration, discovery, and innovation has preserved the United States' role as both a leader in world aviation and as the preeminent spacefaring nation. It is NASA's mission to:

- Advance human exploration, use and development of space;
- Advance and communicate scientific knowledge and understanding of the Earth, the Solar System, and the Universe;
- Research, develop, verify and transfer advanced aeronautics and space technologies.

The outcomes of NASA's activities contribute significantly to the achievement of America's goals in five key areas:

- Economic growth and security - NASA conducts aeronautics and space research and develops technology in partnership with industry, academia, and other federal agencies to keep America capable and competitive.
- Increased understanding of science and technology – NASA communicates widely the content, relevancy, and excitement of our mission and discoveries to inspire and increase the understanding and the broad application of science and technology.
- Protection of Earth's Environment - NASA studies the Earth as a planet and as a system to understand global climate change, enabling the world to address environmental issues.
- Educational Excellence - NASA involves the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds.
- Peaceful Exploration and Discovery - NASA explores the Universe to enrich human life by stimulating intellectual curiosity, opening new worlds of opportunity, and uniting nations of the world in this quest.

Achieving our goals and objectives over the first quarter of the 21st century will contribute to national priorities: the protection of Earth's fragile environment, educational excellence, peaceful exploration and discovery, and economic growth and security.

STRATEGY FOR ACHIEVING OUR GOALS

The NASA budget request for FY 2002 includes both near-term priorities–flying the Space Shuttle safely and building the International Space Station–and longer-term investments in America's future–developing more affordable, reliable means of acces s to space and conducting cutting-edge scientific and technological research. It draws on NASA's strengths in engineering and science and reflects the revolutionary insights and capabilities on the horizon in areas such as biotechnology, nanotechnology, and information technology. It describes our vision for expanding air and space frontiers, serving America, and improving life on Earth. The President's budget request for NASA for FY 2002 supports these goals.

NASA's budget request for FY 2002 is reflected in three appropriations:

Human Space Flight (HSF) - provides funding for HSF activities, and for Safety, mission assurance and engineering activities supporting the Agency. The HSF activities include development and operations of the Space Station, the Space Station research program, and operation of the Space Shuttle. This includes development of contingency capabilities for the Space Station, high priority investments to improve the safety of the Space Shuttle, and required construction projects in direct support of the Space Station and Space Shuttle programs. This appropriation also provides for salaries and related expenses (including travel); design, repair, rehabilitation, and modification of facilities and construction of new facilities; maintenance, and operation of facilities; and other operations activities supporting human space flight programs; and space operations, safety, mission assurance and engineering activities that support the Agency.

Science, Aeronautics and Technology (SAT) - provides for the science, aeronautics and technology activities supporting the Agency. These activities include space science, biological and physical research, earth science, aerospace technology, and academic programs. This appropriation also provides for salaries and related expenses (including travel); design, repair, rehabilitation, and modification of facilities and construction of new facilities; maintenance, and operation of facilities; and other operations activities supporting science, aeronautics, and technology programs.

Inspector General – provides funding for the workforce and support required to perform audits and evaluations of NASA's programs and operations.

The NASA Strategic Plan describes how we will pursue our vision, implement our mission, and seek answers to fundamental questions of science and technology that provide the foundation for our goals and objectives. In addition to our vision and mission, NASA's strategic architecture consists of five Strategic Enterprises supported by four Crosscutting Processes. The Strategic Enterprises are NASA's primary mission areas. The Agency's goals and objectives are organized by Strategic Enterprise and Crosscutting Process. These goals and objectives represent a balanced set of science, exploration, and technology development outcomes that we believe can be accomplished over the next 25 years.

The following is a broad description of the focus of each Strategic Enterprise:

Space Science - The activities of the Space Science Enterprise seek to chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planetary bodies, and life. The Enterprise asks basic questions that have eternally perplexed human beings: How did the universe begin and evolve? How did we get here? Where are we going? Are we alone? The Space Science Enterprise develops space observatories and directs robotic spacecraft into the solar system and beyond to investigate the nature of the universe.

The quest for this information, and the answers themselves, maintains scientific leadership, excites and inspires our society, strengthens education and scientific literacy, develops and transfers technologies to promote U.S. competitiveness, fosters international cooperation to enhance programs and share their benefits, and sets the stage for future space ventures.

Earth Science - The activities that comprise this Enterprise are dedicated to understanding the total Earth system and the effects of humans on the global environment. This pioneering program of studying global climate change is developing many of the capabilities that will be needed for long-term environment and climate monitoring and prediction. Governments around the world need information based on the strongest possible scientific understanding. The unique vantage-point of space provides information about the Earth's land, atmosphere, ice, oceans, and biota as a global system, which is available in no other way. In concert with the global research community, the Earth Science Enterprise is developing the understanding needed to support the complex environmental policy decisions that lie ahead.

Human Exploration and the Development of Space - The Human Exploration and Development of Space (HEDS) Enterprise seeks to expand the frontiers of space and knowledge by exploring, using, and enabling the development of space. HEDS asks questions to improve human possibilities both on Earth and in space. How do we design systems to make possible safe and efficient human exploration and commercial development of space? What are the resources of the solar system? Where are they? Are they accessible for human use? How can we ensure that humans can be productive in and beyond Earth orbit? HEDS is building the International Space Station to provide a continuously operating research platform and to prepare the way for robotic and human exploration even farther into space.

Biological and Physical Research - The Biological and Physical Research (BPR) Enterprise affirms NASA's commitment to the essential role biology will play in the 21st century, to establish the core of biological and physical sciences research needed to support Agency strategic objectives. BPR will foster and enhance rigorous interdisciplinary research, closely linking fundamental biological and physical sciences in order to develop leading-edge, world-class research programs. BPR is dedicated to using the unique characteristics of the space environment to understand biological, physical, and chemical processes, conducting science and technology research required to enable humans to safely and effectively live and work in space, and transferring knowledge and technologies for Earth benefits. BPR also fosters commercial space research by the private sector towards new or improved products and/or services on Earth, in support of the Agency's mandate to encourage the commercial use of space.

Aerospace Technology - The Aerospace Technology Enterprise works to maintain U.S. preeminence in aerospace research and technology. The Enterprise aims to radically improve air travel, making it safer, faster, and quieter as well as more affordable, accessible, and environmentally sound. The Enterprise is also working to develop more affordable, reliable, and safe access to space; improve the way in which air and space vehicles are designed and built; and ensure new aerospace technologies are available to benefit the public. NASA, and its predecessor, the National Advisory Committee for Aeronautics, have worked closely with U.S. industry, universities, and other Federal agencies to give the United States a preeminent position in Aeronautics. NASA's Aeronautics program pioneers the identification, development, verification, transfer, application and commercialization of high-payoff aeronautics technologies. Activities pursued as part of this Enterprise emphasize customer involvement, encompassing U.S. industry, the Department of Defense, and the Federal Aviation Administration. NASA is playing a leadership role as part of a

Government-industry partnership to develop breakthrough technology that will help the aviation community cut the fatal accident rate five-fold within ten years and ten-fold within twenty years. NASA also supports the development of technologies to address airport crowding, aircraft engine emissions, aircraft noise, and other issues that could constrain future U.S. air system growth. NASA's program to advance space transportation by creating a safe, affordable highway through the air and into space is developing new technologies aimed at access to space. The targeted technologies will reduce launch costs dramatically over the next decade, as well as increase the safety and reliability of current and future generation launch vehicles. Additionally, new plateaus of performance for in-space propulsion will be established, while reducing cost and weight.

NASA's ability to inspire and expand the horizons of present and future generations rests on the success of these efforts to maintain this nation's leadership in aerospace.

PLANS AND ACCOMPLISHMENTS

Human Space Flight

Space Station

The International Space Station (ISS) is an international laboratory in low Earth orbit on which American, Russian, Canadian, European, and Japanese astronauts will conduct unique scientific and technological investigations in a microgravity environment. The goal of the Station is to support activities requiring the unique attributes of humans in space and establish a permanent human presence in Earth orbit. The proposed budget provides funding for the continued development of the vehicle and its research components and for current operations, assembly and utilization of the station. With several assembly missions successfully completed, the budget includes funding to keep subsequent assembly missions on schedule through U.S. Core Station Complete, currently planned for late 2003 – early 2004, and for early research commensurate with the build-up of on-orbit utilization capabilities and resources.

Between January 2000 and January 2001, the Russian Service Module, the Z1 and SO trusses, the control moment gyros, the first photo-voltaic array and battery sets, initial thermal radiators, communication equipment, and the U.S. Laboratory were assembled on-orbit. A permanent human presence in space was achieved with the launch of Expedition 1. The first phases of multi-element integrated testing (MEIT) were completed. Crew training, payload processing, hardware element processing, and mission operations were supported. During the remainder of 2001, Expedition 2 will be deployed, and Phase 2 of the station assembly will be completed with the launch of the airlock. Preparations will continue for the start of Phase 3 and the first shuttle mission dedicated to research utilization is expected to be launched in mid-2002.

Russian Program Assurance (RPA) is contained within the Space Station budget and provides funding for contingency activities to address ISS program requirements resulting from delays or shortfalls on the part of Russia in meeting its commitments to the ISS program. Key elements of the RPA program have been the Interim Control Module (ICM), developed by the U.S. Naval Research Laboratory (NRL), and the U.S. Propulsion Module. With the successful launch of the Russian Service Module, and escalating costs for Space Station, including RPA components, NASA reassessed its Space Station priorities and the need for planned RPA hardware. In FY 2000, the ICM was placed in "call-up" mode and stored at NRL. Work on the original Propulsion Module design was terminated, and in FY 2001 funds for the Propulsion Module were redirected to cover cost increases in the baseline program. This left logistics contingency funding and funds for potential procurement of safety-related Russian goods and services in the RPA budget. Based on recent operational experience, continuing flight software and hardware integration issues, obsolescence issues, and realization that earlier assembly phase cost estimates were low, NASA concluded that the program baseline could not be executed on schedule within approved funding levels. A reassessment of the ISS Program budget baseline was started in FY 2000 and continued into FY 2001. The initial results, based on conservative estimating assumptions, showed a budget shortfall of up to $4 billion over 5 fiscal years. To remain within the Agency's budget marks, NASA redirected funds from remaining high-risk, high-cost hardware development, including the Habitation Module and Crew Return Vehicle (CRV), as well as funds from the RPA budget mentioned above, to ensure that ISS would stay within budget, while assembly continues though U.S. Core Station Complete (deployment of Node 2 on flight 10A). This will allow for the integration of flight hardware being provided by the International Partners. In addition, the ISS Research Program is being realigned to match the on-orbit capability build-up as the program moves toward U.S. Core Complete. NASA will continue to pursue atmospheric testing of the X-38 and is assessing the affordability of completing the space flight test relative to other program priorities. Options for provision of a crew return capability and Habitat capability to support the desired increase in crew size from 3 to 6 will be discussed with the international partners. However, U.S. contributions to such capabilities will be dependent on the availability of funds within the President's five-year budget plan for Human Space Flight, technical risks, and the Administration's confidence in Agency cost estimates. Over the next several years, the Agency will press ahead with ISS assembly and the integration of the partners' research modules. Research operations on board the ISS have been expanding since they began in FY 2000 and will greatly exceed any previous capabilities for research in space including Skylab, Shuttle, or Mir.

Payload and Expendable Launch Vehicle (ELV) Support

During 2001, six pallets will be used in Space Shuttle missions. In FY 2001 and 2002, over 20 major and secondary payloads will be supported, including major hardware for ISS assembly. The ELV Mission Support budget provides funds for acquiring requisite launch services to meet all NASA requirements and for technical insight of commercially provided launch services. Advanced mission design/analysis and leading edge integration services are provided for the full range of NASA missions under consideration for launch on ELVs. During FY 2000, six ELV missions were successfully launched. Integration and technical management of 13 missions are planned for launch in FY 2001. In FY 2002 support for eight missions is planned.

Investments and Support

The Human Exploration and Development of Space (HEDS) Technology and Commercialization Initiative (HTCI) began in FY 2001. HTCI will continue in FY 2002 to focus on human space exploration and development activities emphasizing highly innovative technologies, advances in science, and enabling synergistic commercial space development efforts.

Project activity will continue in FY 2002 to ensure NASA's rocket propulsion test capabilities are properly managed and maintained in world class condition. The project will significantly enhance our ability to properly manage NASA's rocket testing activities and infrastructure across all four participating NASA centers.

Engineering and technical base (ETB) activity will continue to support the institutional capability in the operation of space flight laboratories, technical facilities, and testbeds; to conduct independent safety, and reliability assessments; and to stimulate science and technical competence in the United States.
Funding for other direct costs associated with Human Space Flight, which were previously funded in the Mission Support account, are now funded as part of investments and support. This includes research and program management costs and non-programmatic construction of facilities costs.

Space Shuttle

The Space Shuttle is a partially reusable space vehicle that provides several unique capabilities to the United States space program. These include retrieving payloads from orbit for reuse, servicing and repairing satellites in space, safely transporting humans to and from space, launching ISS components and providing an assembly platform in space, and operating and returning space laboratories. In FY 2000, the Space Shuttle launched four flights successfully including the emergency HST Servicing Mission 3A which replaced failing gyros on the HST and the Shuttle Radar Topography Mission (SRTM), a joint DOD/NASA payload to study the earth. The Space Shuttle also visited the ISS two more times, for both assembly and maintenance.

Seven flights are planned during FY 2001, all of which are ISS assembly and servicing missions. The first crew began permanent occupation and presence aboard the ISS in FY 2001. In FY 2002, seven flights are planned including a dedicated microgravity research flight and another HST Servicing Mission (HST-3B) and five ISS assembly and servicing missions. The President's Budget supports key Space Shuttle safety investments as part of NASA's Integrated Space Transportation Plan.

Safety, Mission Assurance and Engineering

The goal of this program is to invest in the safety and success of NASA missions by assuring that sound and robust policies, processes, and tools for safety, reliability, quality assurance, and engineering disciplines are in place and applied throughout NASA. The program also examines long-term technology requirements for NASA's strategic objectives.

Science, Aeronautics and Technology

Space Science

The Space Science program seeks to answer fundamental questions concerning: the galaxy and the universe; the connection between the Sun, Earth and heliosphere; the origin and evolution of planetary systems; and the origin and distribution of life in the universe. The Space Science program is comprised of a base program of' research and development activities, including research and flight mission activities, and major space-based facilities.

In 2000, the Space Science program produced many notable scientific accomplishments. Scientists using data from NASA's Mars Global Surveyor spacecraft camera found features that suggest there may be current sources of liquid water at or near the surface of the red planet. The water supply may be about 100 to 400 meters (300 to 1,300 feet) below the surface, and limited to specific regions across the planet. Additional MGS images revealed layers of sedimentary rock that paint a portrait of an ancient Mars that long ago may have featured numerous lakes and shallow seas. These regions of sedimentary layers on Mars are spread out and scattered around the planet.

Solar and Heliospheric Observatory (SOHO) scientists have, for the first time, imaged solar storm regions on the side of the Sun facing away from the Earth. A week's advance warning of potential bad weather in space is now possible thanks to these SOHO measurements. Detailed images from the Transition Region and Coronal Explorer (TRACE) mission of giant fountains of fast-moving, multimillion-degree gas in the outermost atmosphere of the Sun have revealed an important clue to a long-standing mystery -- the location of the heating mechanism that makes the corona 300 times hotter than the Sun's visible surface. Scientists are interested in the corona, which appears as a halo of light seen by the unaided eye during a total solar eclipse, because eruptive events in this region can disrupt high-technology systems on Earth. Astronomers also hope to use the solar corona studies to better understand other stars.

The balloon-borne BOOMERANG sub-millimeter telescope mapped the faint light left over from the Big Bang, revealing the earliest structure in the Universe that later became the vast, soap bubble-shaped clusters of galaxies that astronomers observe today. BOOMERANG confirmed that the Universe is flat (Euclidean) and that the expansion of the universe is accelerating.

The Shoemaker Near Earth Asteroid Rendezvous (NEAR) mission became the first spacecraft to orbit an asteroid on February 14, 2000. The mission has returned stunning images and other data of the asteroid Eros, resulting in numerous discoveries throughout the year. Most recently, NEAR made history again by becoming the first spacecraft ever to touch down on the surface of a small solar system body.

Scientists used the Chandra X-ray Observatory to examine a mid-mass black hole in the galaxy M82. This black hole may represent the missing link between smaller stellar black holes and the supermassive black holes found at the centers of galaxies. A Hubble Space Telescope census finds that the mass of a supermassive black hole is directly related to the size of a the bulge of stars at the center of its host galaxy. This suggests that the evolution of galaxies and their host black holes is intimately linked.

The Cassini spacecraft, on its way to meet Saturn in 2004, flew by Jupiter in December and performed joint science operations with Galileo.

The Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) was successfully launched in March 2000, and has provided the first large-scale pictures of the Earth's magnetic field.

The NASA budget request for FY 2002 funds a robust program of Mars exploration for the next decade. Following the loss of the Mars Climate Orbiter and the Mars Polar Lander in 1999, an in-depth review of our Mars exploration program found significant flaws in program formulation and execution, and made recommendations for the future exploration of Mars. Consistent with those recommendations, we are pressing forward with the development of a set of future Mars missions to establish a sustained presence at Mars. By means of orbiters, landers, rovers and sample return missions, NASA's revamped campaign to explore Mars is poised to unravel the secrets of the red planet's past environments, the history of its rocks, the many roles of water and, possibly, evidence of past or present life. The Mars Global Surveyor entered Mars orbit in September 1997, and is still performing flawlessly. The 2001

Mars Odyssey will be launched in April 2001, and we have started development of the twin Mars Environmental Rovers for launch in 2003. Additional Mars Exploration Program funding provided in the President's FY 2002 Budget will enable: a robust 2005 Mars Reconnaissance Orbiter; a competitively selected 2007 Mars Scout mission; an accelerated 2009 Mars Mobile Laboratory mission; U.S. participation in foreign missions to Mars; and technologies for the next decade of robotic Mars missions.

Development activities continue on the Relativity (Gravity Probe-B) mission, which is now scheduled for launch in 2002, and the Space Infrared Telescope Facility (SIRTF), with launch planned for July 2002. Launch of the Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED) mission is expected to occur this summer (2001). Development activities on the Stratospheric Observatory for Infrared Astronomy (SOFIA) continue. Funding for the Hubble Space Telescope (HST) continues to support operations, and preparations for the last planned Hubble servicing missions, servicing mission 3B in early FY 2002 and servicing mission 4 in FY 2004, when new science instruments will be installed.

In the Explorer program, development activities continue for the Microwave Anisotropy Probe (MAP), which will be launched in summer 2001; the Full-sky Astrometric Mapping Explorer (FAME), scheduled for launch in 2004, and Swift, a multi-wavelength observatory for gamma-ray burst astronomy, to be launched in 2003. Three Small (SMEX) missions continued development in FY 1999: the High Energy Spectroscopic Imager (HESSI) is to launch in spring 2001; the Galaxy Evolution Explorer (GALEX) will launch in early FY 2002; and the Two Wide-Angle Neutral Atom Spectrometers (TWINS) will be launched in 2002 and 2004.

In the Discovery program, the fourth mission, Stardust, was launched on schedule in February 1999, and is operating normally during its cruise to comet Wild-2, with the encounter scheduled for 2004. Two Discovery missions selected in 1997 are proceeding: the Comet Nucleus Tour (CONTOUR) began development in CY 2000 and will be launched in 2002; the Genesis solar wind sample return mission has nearly finished development and will be launched in summer 2001. Two new missions were selected for implementation during 1999: The MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) mission to orbit Mercury; and the Deep Impact mission to fly by and fire an impactor into a comet. Both MESSENGER and Deep Impact are planned for launch in 2004.

The New Millennium program is providing flight demonstrations of critical new technologies which will reduce the mass and cost of future science and spacecraft subsystems, while maintaining or improving mission capabilities. In 1999, NASA selected the Nanosat Constellation Trailblazer as the Space Technology-5 New Millennium mission. This mission will feature three very small satellites (each about the size of a large birthday cake), that will fly in formation and test eight technologies in the harsh space environment near the boundary of Earth's protective magnetic field. The Flight Validation program has been restructured to enhance openness and competition as well as to increase the number of opportunities for technologies to be flight-validated. An Announcement of Opportunity for Space Technology-6 technologies was recently released, and in January 2001, eight teams from industry, universities and NASA centers were selected to develop new technology concepts, such as advanced solar power and optical communications, for future NASA missions. The teams will study flight test options during a six-month phase for defining the technology concepts. NASA then plans to select up to five of the concepts for Space Technology-6 (ST-6), the next New Millennium Program project, which will flight-test the new technology concepts in 2003 and 2004.

The President's FY 2002 Budget also provides funding for a new Planetary Propulsion program. This program will competitively develop advanced propulsion systems that will reduce the flight time for future robotic missions to the planets and other science targets in the solar system.

Biological and Physical Research

In FY 2001, the Office of Biological and Physical Research (OBPR) was created as an independent research organization and a fifth strategic enterprise, by the restructuring of the Office of Life and Microgravity Sciences and Applications (OLMSA). The Enterprise uses the unique environment of space to understand the effect of gravity on biological systems and to conduct research in the areas of fluid physics, combustion science, fundamental physics, materials science and biotechnology.

In FY 2000, Space Shuttle Mission STS-101 flew two commercial research payloads which grew large biological crystals in space and investigated the effects of microgravity on the efficiency of genetically transforming plant seeds. Also during FY 2000, the Protein Crystal Growth-Enhanced Gaseous Nitrogen Dewar (PCG-EGN), was used aboard ISS to crystallize proteins for later analysis.

In FY 2001, the first rack of the Human Research Facility (HRF) will be deployed to the International Space Station, and OBPR will begin initial operations of this facility. Construction continues on the Booster Applications Facility at Brookhaven National Laboratory. In FY 2001, research in bioastronautics increased to accelerate development of countermeasures that will improve the health and safety of astronauts aboard the International Space Station (ISS). Devices and countermeasures developed through this initiative may also have many health benefits on Earth. The first four commercial research payloads, investigating antibiotic production, protein crystal growth, agricultural research, and materials research, will be flown on the International Space Station in FY 2001.

During FY 2002, OPBR will continue to demonstrate key technology capabilities for human support, such as advanced techniques for water processing, solid waste processing, air revitalization, biomass production, food processing, and thermal control. In addition, the office will continue work in fundamental biology and bioastronautics to increase knowledge and address critical questions in crew health and safety by conducting investigations on the Space Shuttle and ISS. These will include investigations of the effect of microgravity on skeletal myofibers, avian development in space, the effects of microgravity on bone as a function of age, changes in gene expression in bacteria in space, and the effects of gravity on plant photosynthesis and respiration. New research projects will be selected in the areas of biotechnology, fluid physics, and materials science, and commercial payloads will be flown on both the Shuttle and aboard ISS.

Earth Science

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather and natural hazards for present and future generations. ESE seeks to answer a question of fundamental importance to science and society: *How is the Earth system changing, and what are the consequences for life on Earth?* To do so, ESE is developing the interdisciplinary research field of Earth System Science, which recognizes that the Earth's land surface, oceans, atmosphere, ice sheets, and life itself all interact in a highly dynamic system. Earth system science is an area of research with immense benefit to the Nation, leading to new knowledge and tools that may improve weather forecasting, agriculture, urban and regional planning, environmental quality, and natural disaster management. ESE has established three goals to pursue in order to fulfill its mission: (1) Science – observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth; (2) Applications – expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology; (3) Technology – develop and adopt advanced technologies to enable mission success and serve national priorities.

In ESE Science, 2000 was another year of substantial accomplishment toward understanding the Earth system. In an 11-day Space Shuttle mission, a new inteferometric synthetic aperture radar technique collected data sufficient to produce the first detailed topographic map of the entire land surface of the Earth between 60°N and 56°S. Landsat 7 completed a global survey of land cover, and the Terra satellite observed the global land and ocean biosphere as it underwent seasonal changes, and showed that snow cover over North America was substantially below normal following the warmest winter on record. The QuikSCAT satellite observed a Connecticut-size iceberg break off of the Antarctic polar ice sheet, and the US and Canada mapped Antarctica for the second time with space-based radar in order to compare with the first and determine rates of change. Using data from the US/Japan Tropical Rainfall Measuring Mission, researchers determined that air pollution affects rainfall rates downwind of its sources. Also in 2000, ESE formulated a new Research Strategy for 2000-2010 to guide research over the next decade, identifying 23 societally important research questions in the Earth system paradigm of variability, forcing, response, consequence and prediction. This Research Strategy will guide ESE's science activities and investments over the next decade.

In ESE Applications, ESE has entered into a variety of partnerships that will demonstrate the goods and services made possible by ESE's research. ESE provides QuikSCAT data in real time to NOAA to improve marine weather forecasting, and has used these data to show that severe storms forming over the oceans can be predicted two days in advance. ESE is working with FEMA to use remote sensing tools to update their flood plain maps throughout the US. In a partnership called AG 2020 with USDA and four growers associations representing 100,000 farmers, ESE is demonstrating how to increase crop productivity, reduce risks to crop health, and manage environmental impacts. With the National Institutes of Health, we are exploring the use of satellite data to predict spread of infectious diseases such as malaria that are highly influenced by weather and climate. Throughout the summer, three ESE satellites tracked devastating wildfires in the western US, providing data to the US Forest Service and regional authorities. ESE held three regional workshops across the US to plan the next generation of applications demonstration projects with State and local governments in infrastructure planning and related topics.

In ESE Technology, the Enterprise launched its first New Millennium Program satellite to demonstrate a variety of new technologies for Earth Science. These include a new instrument to produce a Landsat-type sensor one-fourth the size of the current Landsat 7 instrument, and the first hyperspectral imager in space, which views the land surface in hundreds of spectral channels rather than the conventional 5 to 7. Sponsored technology research with universities, industry and other government laboratories moved 20 different remote sensing instrument concepts one step closer to reality on an established scale of technology maturity. These will substantially reduce the cost and enhance the capability of new satellites over the next decade or more.

ESE is in the midst of deployment of the Earth Observing System (EOS), a set of spacecraft and associated interdisciplinary science investigations to initiate a long-term data set of key parameters required for the study of global climate change. The first four EOS satellites are already in orbit, including the flagship Terra mission launched in 1999. The remaining EOS satellites will be launched through 2003, including Aqua (2001) to study the water cycle and atmospheric circulation, and Aura (2003) to probe the chemistry of the upper and lower atmosphere. Complementing EOS is a series of small, focused Earth System Science Pathfinder missions to explore Earth system processes never before examined globally from space. Data from the EOS satellites already in orbit are being acquired, processed, and distributed by the EOS Data and Information System (EOSDIS), which is currently handling more than 1 terabyte of data per day. EOSDIS handled 1.5 million user queries for over 8 million products in 2000. EOSDIS continues to evolve as new satellites are launched, and as new partners are added to produce data products with innovative applications.

As it deploys EOS, ESE is also planning for the future. For example, a Landsat Data Continuity Mission is being formulated in partnership with USGS, and will be implemented as a commercial data purchase, if possible. ESE is also planning for the transition of several of its key research observations to the Nation's weather satellite system. The DoD, NOAA and NASA have established an Integrated Program Office (IPO) to create a converged civilian and military weather satellite system called the National Polar-orbiting Operational Environmental Satellite System (NPOESS) to replace the present generation of separate systems. NASA and the IPO are jointly funding the NPOESS Preparatory Project (NPP) that will simultaneously continue key measurements begun by EOS and demonstrate instruments for NPOESS. The NPP will save money for both organizations by combining essential atmospheric and Earth surface observations on a single platform, and by seeking to meet both climate science and operational weather requirements with the same advanced instruments.

ESE data products and research are a major contribution to the US Global Change Research Program, an interagency collaboration overseen by the Committee on Natural Resources of the National Science and Technology Council. Because Earth science is inherently global in scope, ESE is engaged in a variety of international partnerships with individual nation's space agencies, and with international consortia such as the World Meteorological Organization. ESE seeks and receives scientific advice on a broad range of topics from the various boards and committees of the National Research Council. These partnerships, together with those above, ensure that NASA's Earth Science Enterprise conducts research at the frontiers of Earth science on questions of practical importance to the Nation.

Aerospace Technology

The mission of this Enterprise is to pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aerospace technologies. Through its research and technology accomplishments, Aerospace Technology promotes economic growth and national security by supporting a safe, efficient national aviation system and affordable, reliable space transportation. In addition, the Aerospace Technology Program supports the development of crosscutting technology to serve the needs of all NASA Enterprises. To meet this challenge, the Enterprise has established three main technology goals and one goal for commercialization. Within the three technology goals a set of objectives has been defined to address current and future National needs. The technologies associated with these objectives are pre-competitive, long-term, high-risk research endeavors with high payoff in terms of market growth, safety, low acquisition cost, consumer affordability and a cleaner environment. The first goal, Revolutionize Aviation, addresses the fundamental, systemic issues in the aviation system to ensure continued growth and development appropriate to the needs of the national and global economies. These systemic issues–safety, capacity, environmental compatibility, and mobility–cut across markets including large subsonic civil transports, air cargo, commuter and general aviation. NASA coordinates its investments and technology objectives in this area with the Federal Aviation Administration and the Department of Defense through the *National Research and Development Plan for Aviation Security, Efficiency, and Environmental*

Compatibility. The second goal, Advance Space Transportation, will create a safe, affordable highway through the air and into space by improving safety, reliability, and operability, while significantly reducing the cost of space transportation systems. With the creation of the Integrated Space Transportation Plan (ISTP), NASA defined a single, integrated investment strategy for all its diverse space transportation efforts. The third goal, Pioneer Technology Innovation, is unique in that it focuses on broad, crosscutting innovations critical to a number of NASA missions and to the aerospace industry in general. Pursuing technology fields that are in their infancy today, developing the knowledge bases necessary to design radically new aerospace systems, and developing tools for efficient, high-confidence design and development, will enable a revolution in aerospace. The fourth goal, Commercialize Technology, is to extend the commercial application of NASA technology for economic benefit and improved quality of life. By partnering with both aerospace and non-aerospace industry as well as academia, the full range of NASA's assets-- technological expertise, new technologies, and research facilities -- are made available to help the Nation.

As planned in the FY 2001 budget request, the Administration's 2002 request includes an increase in funding for the 2nd Generation Reusable Launch Vehicle (RLV) Program, although this request is lower than last year's projections primarily due to reallocation of Crew Return Vehicle placeholder funding to the International Space Station. Low-cost space transportation remains the key enabler for a more aggressive civil space program. NASA's Integrated Space Transportation Planning activities have identified a strategy based upon competition, safety, industry leadership and affordable requirements. Funding supports aggressive technical risk reduction and advanced development for multiple reusable launch vehicle concepts. Identification and preliminary development of NASA-unique systems and near-term pursuit of technologies required for alternative access for key Space Station needs are also both critical elements of the Integrated Space Transportation Plan (ISTP). All of these efforts combined will move NASA closer to a full and open RLV competition in the middle of this decade to meet NASA's human space flight needs by the end of the decade. In FY 2001, NASA will make the first risk reduction activity awards to industry under the 2nd Generation RLV Program. These risk reduction activities will continue through FY 2002 and feed future steps toward the launch services competition at mid-decade. The President's FY 2002 Budget prescribes several key management reforms in areas like vehicle requirements and program integration that will help ensure the success of this important undertaking.

The Administration's request includes a significant investment in computing and information technology developments and also increases the investment in biotechnology and nanotechnology -- the revolutionary technologies of the 21st Century. To ensure the highest quality research and strong ties to NASA's mission, these investments will be guided by technology development agreements signed by customers in other NASA Enterprises and subject to external, independent reviews. A significant portion of these investments will be externally competed. The Administration's request supports the implementation of six University-based Research, Education, and Training Institutes (RETIs). This will strengthen NASA's ties to the academic community through long-term sustained investment in areas of science and technology critical to NASA's future. To ensure the highest quality research and training and infusion of new ideas, these RETIs will be subject to independent, external reviews and recompetition at regular intervals, including mandatory sunsets after ten years. The Administration's request also supports a 21st Century aerospace vehicle technology program. This research will develop and verify critical technologies that provide leapfrog capabilities for aerospace vehicles that will be able to change their shape in flight like birds to optimize performance or perform complex maneuvers in complete safety, and be capable of self repair when damaged.

The President's request for NASA maintains investments in technology development activities that will address the challenges (safety, environmental impact, capacity, noise reduction) that face the Nation's air system. As part of NASA's response to the national goal of reducing aircraft accidents by a factor of 5 by the end of FY 2007, NASA began a focused Aviation Safety Program (AvSP) in FY 2000 that builds on the extensive safety related activities of the Base Research and Technology (R&T) Programs. The base technologies provided the foundation for focused safety development efforts in the future, as well as some near-term achievements. For example, in FY 2000, AvSP produced an icing training program for general aviation and commuter pilots, completed a flight evaluation of an initial national capability for digital data link and graphical display of weather information, and demonstrated a concept for the integration of air traffic control runway incursion information onto aircraft flight deck displays. In FY 2001, the AvSP will complete a laboratory demonstration of a fuel system modification to reduce flammability, define the architecture for an integrated onboard health management system, and down-select synthetic vision concepts suitable for retrofit in commercial, business, and general aviation aircraft. The Base R&T Programs will continue to develop the technologies that will contribute to the FY 2007 goal. For example, in FY 2002, NASA will complete an interim progress assessment utilizing the technology products of the Aviation Safety program as well as related Aerospace Base R&T efforts to demonstrate potential to meet the National Goal.

NASA also continued its efforts to reduce the environmental impact associated with aviation systems. The Ultra Efficient Engine Technology (UEET) program is a focused program that began in FY 2000. UEET is planned and designed to develop high-payoff, high-risk technologies to enable the next breakthroughs in propulsion systems and to spawn a new generation of high-performance, operationally efficient and economical, reliable and environmentally compatible U.S. aircraft. In FY 2002, UEET will, in sector combustor tests, demonstrate initial 70% low NOx reduction, relative to 1996 International Civil Aviation Organization (ICAO) standards for Landing/Takeoff conditions in subsonic engines. Similarly, progress is being achieved in noise abatement efforts. In 2000, NASA validated the technologies required to reduce community noise impact by up to 10 dB relative to 1992 technology. In FY 2001 and FY 2002, NASA will: select engine system and airframe system technologies necessary to achieve a 3-dB aircraft system noise reduction beyond the 1997 baseline, establish the influence of wind and temperature gradients on community noise impact, and release the beta version of an improved advanced noise prediction code. Also in FY 2002, source diagnostics tests will be completed, giving engine component designers insight into the fundamental physics of the mechanisms that generate broadband fan noise. The data generated by these tests will be used to improve the computational algorithms used in computer codes to predict engine noise. The design of an advanced concept for reduced jet noise will be initiated for testing at laboratory scale later in the Quiet Aircraft Technology program.

In FY 2000, NASA's Aviation System Capacity program demonstrated technologies in a realistic Terminal Area environment achieving a 12-15% increase in single-runway throughput and proving the ability to space aircraft closer than 3,400 feet on parallel runways while meeting all Federal Aviation Administration (FAA) safety criteria. In FY 2001, NASA will demonstrate transition airspace decision support tools for: (1) Air Traffic Control (ATC)/airline operations center and ATC/cockpit information exchange, and (2) conflict resolution. In FY 2002 NASA will demonstrate an interoperable suite of at least two decision support tools for arrival, surface and departure operations and begin an activity entitled AvSTAR which will undertake a Virtual Airspace Modeling project to produce a high-fidelity computer model of the Nation's aviation system. This model will help the FAA and NASA develop new operational concepts and better understand the benefits of new technologies for reducing aviation system congestion and delays while improving aviation safety.

Building on its world-record-setting performances, the Environmental Research Aircraft and Sensor Technology (ERAST) project modified the Centurion solar-powered remotely piloted aircraft (RPA) to a wingspan configuration of greater than 245 feet, renamed the aircraft Helios, and continued flight testing in FY 2000. This configuration will be more suitable for extreme endurance as well as short flights to the 100,000 ft. altitude. In FY 2001, the Flight Research program will demonstrate a solar-powered RPA at 100,000 ft and complete development of a heavyweight energy storage system under the ERAST project. Both achievements will demonstrate technologies that will provide atmospheric satellites for commercial use, disaster relief efforts such as communication relays and real time sensing, and will increase the Nation's capability to make scientific sampling high in the atmosphere. In FY 2002 flight validation of an experimental, consumable fuel, RPA design will enable an enhanced prototype vehicle that meets the prescribed set of Earth Science RPA platform requirements.

The Commercial Technology Program's focus in FY 2000 was continued investment of 10-20 percent of the NASA R&D budget in commercial partnerships with industry and a more efficiently administered program. Based on experience to date, these commercial partnerships are expected to increase the return on the Government's R&D investment, allowing NASA to do more with limited funds, and strengthening the international competitiveness of key industry sectors. In FY 2001 and 2002, the program will continue to emphasize innovative commercial partnerships with industry and continue to refine and enhance a technology and partnership database. In addition, the Small Business Innovative Research programs will pursue increased use and expanded commercial application of the developed technology.

Space Operations

The primary goal of space operations is to provide highly reliable and cost-effective space operations services in support of NASA's science and aeronautics programs. In addition, support is provided to interagency, international, and commercial space-faring enterprising on a reimbursable basis. The Space Communications program is composed of Operations, Mission and Data Service Upgrades, Tracking and Data Relay Satellite Replenishment, and Technology Projects, as well as spectrum management and data standards coordination. Services are provided to a large number of NASA missions including planetary and interplanetary missions; human space flight missions, near-earth and earth orbiting missions; and sub-orbital and aeronautical flight tests. A Consolidated Space Operations Contract (CSOC) was successfully implemented by the Space Operations Management Office at Johnson Space Center and the Lockheed Martin Space Operations Company. The CSOC provides end-to-end mission and data services to both NASA and non-NASA customers. A total of nine contracts have been consolidated to date, and seven further contracts are to be consolidated in FY 2001 and FY 2002. Management responsibility for all Wide Area Network data distribution services for all human space flight, earth orbiting and deep space missions and NASA administrative communications was outsourced by CSOC in FY 2000. Development of the TDRS Replenishment Spacecraft is ongoing, with the first satellite launched in FY 2000.

Academic Programs

The goal of Academic Programs is educational excellence: NASA involves the educational community in our endeavors to inspire America’s students, create learning opportunities, and enlighten inquisitive minds. NASA’s Education Program brings students and educators at all levels into its missions and its research as participants and partners, providing opportunities for a diverse group of educators and students to experience first hand involvement with NASA personnel, facilities, and research and development activities. Academic Programs includes the Minority University Research Program, with a goal to expand NASA's research base by strengthening the research capabilities of minority universities and colleges; to contribute to the scientific and technological workforce; and to promote educational excellence. The range of activities conducted under this program will continue to capture the interest of all students in science and technology, develop talented students at the undergraduate and graduate levels, provide research opportunities for students and faculty members at NASA centers, and strengthen and enhance the research capabilities of the Nation's colleges and universities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLAR)

	*FY 2000	*FY 2001	*FY 2002 REQUEST
HUMAN SPACE FLIGHT	**7,053.9**	**7,163.4**	**7,296.0**
INTERNATIONAL SPACE STATION	2,323.1	2,112.9	2,087.4
SPACE SHUTTLE	2,999.7	3,118.8	3,283.8
PAYLOAD & ELV SUPPORT	79.9	90.0	91.3
HEDS INVESTMENTS AND SUPPORT	1,112.2	1,272.5	1,303.5
SPACE OPERATIONS	496.0	521.8	482.2
SAFETY, MISSION ASSURANCE & ENGINEERING	43.0	47.4	47.8
SCIENCE, AERONAUTICS & TECHNOLOGY	**6,527.9**	**7,066.9**	**7,191.7**
SPACE SCIENCE	2,524.1	2,624.7	2,786.4
BIOLOGICAL & PHYSICAL RESEARCH	340.3	378.8	360.9
EARTH SCIENCE	1690.3	1716.2	1515.0
AEROSPACE TECHNOLOGY	1,834.4	2,214.5	2,375.7
ACADEMIC PROGRAMS	138.8	132.7	153.7
INSPECTOR GENERAL	**20.0**	**22.9**	**23.7**
TOTAL AGENCY	**13,601.8**	**14,253.2**	**14,511.4**

**Restructured to reflect new appropriation structure.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLAR)

SHOWN IN OLD BUDGET STRUCTURE
FOR DISPLAY ONLY

	FY 2000 OPLAN	FY 2001 OPLAN	FY 2002 BUDGET
HUMAN SPACE FLIGHT	**5,487.9**	**5,450.9**	**5,584.5**
INTERNATIONAL SPACE STATION	2,323.1	2,112.9	2,087.4
SPACE SHUTTLE	2,999.7	3,118.8	3,283.8
PAYLOAD & ELV SUPPORT	79.9	90.0	91.3
HEDS INVESTMENTS AND SUPPORT	85.2	129.2	122.0
SCIENCE, AERONAUTICS & TECHNOLOGY	**5,582.4**	**6,177.1**	**6,162.7**
SPACE SCIENCE	2,193.8	2,321.0	2,453.0
BIOLOGICAL & PHYSICAL RESEARCH	274.7	312.9	291.3
EARTH SCIENCE	1,443.4	1,484.6	1,278.0
AEROSPACE TECHNOLOGY	1,125.4	1,404.1	1,504.5
MISSION COMMUNICATIONS SERVICES	406.3		
*SPACE OPERATIONS		521.8	482.2
ACADEMIC PROGRAMS	138.8	132.7	153.7
MISSION SUPPORT	**2,511.5**	**2,602.3**	**2,740.5**
SAFETY, MISSION ASSURANCE & ENGINEERING	43.0	47.4	47.8
SPACE COMMUNICATION SERVICES	89.7		
RESEARCH & PROGRAM MANAGEMENT	2,199.7	2,275.4	2,460.5
CONSTRUCTION OF FACILITIES	179.1	279.5	232.2
INSPECTOR GENERAL	**20.0**	**22.9**	**23.7**
TOTAL AGENCY	**13,601.8**	**14,253.2**	**14,511.4**

**Space Operations reflects the merging of Mission Communication Services and Space Communication Services.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
FISCAL YEAR 2002 ESTIMATES
SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(IN MILLIONS OF REAL YEAR DOLLARS)

	TOTAL	Human Space Flight	Science, Aero, & Technology	Mission Support	Inspector General
FISCAL YEAR 2000					
VA-HUD INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 2000 (P.L. 106-74)	**13,652.7**	5,510.9	5,606.7	2,515.1	20.0
FY 2000 RESCISSION (P.L. 106-113)	**-51.9**	-23.0	-25.8	-3.1	
TRANSFERS TO OTHER AGENCIES (P.L. 106-58)	**-0.3**			-0.3	
FY 2000 EMERGENCY SUPPLEMENTAL APPROPRIATIONS ACT, (P.L. 106-246)	**1.5**		1.5		
LAPSE OF FY 2000 UNOBLIGATED FUNDS	**-0.3**			-0.2	-0.1
TOTAL FY 2000 BUDGET PLAN	**13,601.7**	**5,487.9**	**5,582.4**	**2,511.5**	**19.9**
FISCAL YEAR 2001 REQUEST	**14.035.3**	5,499.9	5,929.4	2,584.0	22.0
VA-HUD INDEPENDENT AGENCIES APPROPRIATIONS ACT, FY 2001 (P.L. 106-377) AS PASSED BY CONGRESS, DIRECTION INCLUDED IN CONFERENCE REPORT H.R. 106-988	**250.0**	-37.0	261.3	24.7	1.0
FY 2001 RESCISSION (P.L. 106-554)	**-31.4**	-12.0	-13.6	-5.7	-0.1
TRANSFERS TO OTHER AGENCIES (P.L. 106-554)	**-0.7**			-0.7	
TOTAL FY 2001 BUDGET PLAN	**14,253.2**	**5,450.9**	**6,177.1**	**2,602.3**	**22.9**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATIONS LANGUAGE

ADMINISTRATIVE PROVISIONS

Notwithstanding the limitation on the availability of funds appropriated for "Human space flight", *or* "Science, aeronautics and technology"[, or "Mission support"] by this appropriations Act, when any activity has been initiated by the incurrence of obligations for construction of facilities as authorized by law, such amount available for such activity shall remain available until expended. This provision does not apply to the amounts appropriated [in "Mission support" pursuant to the authorization] for *institutional* minor revitalization and construction of facilities, and i*nstitutional* facility planning and design.

Notwithstanding the limitation on the availability of funds appropriated for "Human space flight", *or* "Science, aeronautics and technology"[,or "Mission support"] by this appropriations Act, the amounts appropriated for construction of facilities shall remain available until September 30, [2003]*2004*.

[Notwithstanding the limitation on the availability of funds appropriated for "Mission support" and "Office of Inspector General", amounts made available by this Act for personnel and related costs and travel expenses of the National Aeronautics and Space Administration shall remain available until September 30, 2001 and may be used to enter into contracts for training, investigations, costs associated with personnel relocation, and for other services, to be provided during the next fiscal year.] Funds for announced prizes otherwise authorized shall remain available, without fiscal year limitation, until the prize is claimed or the offer is withdrawn.

[Unless otherwise provided for in this Act or in the joint explanatory statement of the committee of conference accompanying this Act, no part of the funds appropriated for "Human space flight" may be used for the development of the International Space Station in excess of the amounts set forth in the budget estimates submitted as part of the budget request for fiscal year 2001]

[No funds in this or any other Appropriations Act may be used to finalize an agreement prior to December 1, 2001 between NASA and a nongovernment organization to conduct research utilization and commercialization management activities of the International Space Station.] *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2001, as enacted by section 1(a)(1) of P.L. 106.377.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATIONS LANGUAGE

GENERAL PROVISIONS

Section 417

Such sums as may be necessary for fiscal year [2001] *2002* pay raises for programs funded by this Act shall be absorbed within the levels appropriated in this Act.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATIONS LANGUAGE

HUMAN SPACE FLIGHT
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses, not otherwise provided for, in the conduct and support of human space flight research and development activities, including research, development, operations, *support* and services; maintenance; construction of facilities including *repair, rehabilitation*, revitalization and modification of facilities, construction of new facilities and additions to existing facilities, facility planning and design, *environmental compliance and restoration*, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; *program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. §§ 5901- 5902; travel expenses; purchase and hire of passenger motor vehicles; not to exceed $20,000 for official reception and representation expenses;* and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, [$5,462,900,000] *$7,296,000,000*, to remain available until September 30, [2002] 2003, *of which amounts as determined by the Administrator for salaries and benefits; training, travel and awards; facility and related costs; information technology services; science, engineering, fabricating and testing services; and other administrative services may be transferred to the Science, Aeronautics and Technology account in accordance with section 312(b) of the National Aeronautics and Space Act of 1958, as amended by Public Law 106-377: Provided, That the authorized funding level for the International Space Station through fiscal year 2006 shall not exceed $8,197,300,000 except in amounts equal to budget reductions in other Human Space Flight programs. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2001, as enacted by section 1(a)(1) of P.L-106-377.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATIONS LANGUAGE

SCIENCE, AERONAUTICS AND TECHNOLOGY
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses, not otherwise provided for, in the conduct and support of science, aeronautics and technology research and development activities, including research, development, operations, *support* and services; maintenance; construction of facilities including *repair, rehabilitation,* revitalization and modification of facilities, construction of new facilities and additions to existing facilities, facility planning and design, *environmental compliance and restoration*, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; *program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. §§ 5901- 5902; travel expenses; purchase and hire of passenger motor vehicles; not to exceed $20,000 for official reception and representation expenses;* and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, [$6,190,700,000] *$7,191,700,000*, to remain available until September 30, [2002] 2003, *of which amounts as determined by the Administrator for salaries and benefits; training, travel and awards; facility and related costs; information technology services; science, engineering, fabricating and testing services; and other administrative services may be transferred to the Human Space Flight account in accordance with section 312(b) of the National Aeronautics and Space Act of 1958, as amended by Public Law 106-377. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2001, as enacted by section 1(a)(1) of P.L-106-377.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATIONS LANGUAGE

INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General in carrying out the Inspector General Act of 1978, as amended, *[$23,000,000] $23,700,000.* *(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2001, as enacted by section 1(a)(1) of P.L-106-377.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES

DISTRIBUTION OF PROGRAM AMOUNT BY INSTALLATION
(Thousands of Dollars)

	Total			Human Space Flight			Science, Aeronautics and Technology			Mission Support		
	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002
Johnson Space Center	4,155,141	4,230,689	4,467,858	3,374,671	3,400,635	4,280,551	364,136	422,958	187,307	416,334	407,096	0
Kennedy Space Center	897,284	922,272	999,940	377,460	357,400	717,179	221,659	268,039	282,761	298,165	296,833	0
Marshall Space Flight Center	2,218,412	2,223,636	2,201,775	1,434,879	1,372,865	1,426,253	444,208	488,947	775,522	339,325	361,824	0
Stennis Space Center	188,231	249,353	187,821	39,986	58,801	100,057	93,865	101,383	87,764	54,380	89,169	0
Ames Research Center	649,333	720,963	717,611	63,060	74,447	70,091	385,994	431,810	647,520	200,279	214,706	0
Dryden Flight Research Center	217,596	218,857	206,003	7,400	10,935	32,565	141,158	138,107	173,438	69,038	69,815	0
Langley Research Center	579,960	660,040	686,846	3,600	4,645	16,805	320,206	394,278	670,041	256,154	261,117	0
Glenn Research Center	575,750	642,197	598,098	52,489	75,505	119,577	301,312	324,370	478,521	221,949	242,322	0
Goddard Space Flight Center	2,308,270	2,423,171	2,451,155	10,600	26,180	196,420	1,876,779	1,980,942	2,254,735	420,891	416,049	0
Jet Propulsion Laboratory	1,246,405	1,363,096	1,363,276	10,435	14,350	150,462	1,211,541	1,324,210	1,212,814	24,429	24,536	0
Headquarters	545,462	575,933	607,317	113,320	55,117	186,040	221,542	302,031	421,277	210,600	218,785	0
Undistributed:												
Inspector General	20,000	22,949	23,700									
TOTAL NASA	13,601,844	14,253,157	14,511,400	5,487,900	5,450,880	7,296,000	5,582,400	6,177,076	7,191,700	2,511,544	2,602,252	0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

OLD STRUCTURE	2000 OPLAN REVISED	2001 OPLAN REVISED	2002 PRES BUDGET	2003	2004	2005	2006
HUMAN SPACE FLIGHT	**5,487.9**	**5,450.9**	**5,584.5**	**5,250.0**	**4,991.5**	**4,841.6**	**4,857.7**
INTERNATIONAL SPACE STATION	2,323.1	2,112.9	2,087.4	1,817.5	1,509.1	1,394.3	1,389.0
SPACE SHUTTLE	2,999.7	3,118.8	3,283.8	3,218.9	3,253.3	3,213.5	3,228.0
PAYLOAD UTILIZATION AND OPERATIONS	165.1						
PAYLOAD AND ELV SUPPORT		90.0	91.3	92.5	100.0	104.7	111.6
INVESTMENTS & SUPPORT		129.2	122.0	121.1	129.1	129.1	129.1
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5,582.4**	**6,177.1**	**6,162.7**	**6,817.6**	**7,385.9**	**7,747.9**	**8,051.4**
SPACE SCIENCE	2,193.8	2,321.0	2,453.0	2,801.5	3,205.2	3,526.5	3,623.9
BIOLOGICAL & PHYSICAL RESEARCH	274.7	312.9	291.3	303.1	322.2	325.0	335.6
EARTH SCIENCE	1,443.4	1,484.6	1,278.0	1,346.1	1,321.0	1,311.0	1,307.6
AEROSPACE TECHNOLOGY	1,125.4	1,404.1	1,504.5	1,852.4	2,107.3	2,144.9	2,343.8
MISSION COMMUNICATION SERVICES	406.3						
SPACE OPERATIONS		521.8	482.2	370.8	286.5	296.8	296.8
ACADEMIC PROGRAMS	138.8	132.7	153.7	143.7	143.7	143.7	143.7
MISSION SUPPORT	**2,511.5**	**2,602.3**	**2,740.5**	**2,893.2**	**2,980.5**	**3,043.4**	**3,136.9**
SAFETY, MISSION ASSURANCE & ENGINEERING	43.0	47.4	47.8	47.8	48.0	48.0	48.0
SPACE COMMUNICATION SERVICES	89.7						
RESEARCH AND PROGRAM MANAGEMENT	2,199.7	2,275.4	2,460.5	2,566.4	2,661.5	2,764.4	2,873.9
CONSTRUCTION OF FACILITIES	179.1	279.5	232.2	279.0	271.0	231.0	215.0
INSPECTOR GENERAL	**20.0**	**22.9**	**23.7**	**24.6**	**25.5**	**26.5**	**27.4**
TOTAL	**13,601.8**	**14,253.2**	**14,511.4**	**14,985.4**	**15,383.4**	**15,659.4**	**16,073.4**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

FULL COST STRUCTURE	**2000***	**2001***	**2002 PRES BUDGET**	**2003**	**2004**	**2005**	**2006**
HUMAN SPACE FLIGHT	**7,053.9**	**7,163.4**	**7,296.0**	**6,881.0**	**6,545.0**	**6,439.0**	**6,494.0**
INTERNATIONAL SPACE STATION	2,323.1	2,112.9	2,087.4	1,817.5	1,509.1	1,394.3	1,389.0
SPACE SHUTTLE	2,999.7	3,118.8	3,283.8	3,218.9	3,253.3	3,213.5	3,228.0
PAYLOAD AND ELV SUPPORT	79.9	90.0	91.3	92.5	100.0	104.7	111.6
INVESTMENTS & SUPPORT	1,112.2	1,272.5	1,303.5	1,333.5	1,348.1	1,381.7	1,420.6
SPACE OPERATIONS	496.0	521.8	482.2	370.8	286.5	296.8	296.8
SAFETY, MISSION ASSURANCE, & ENGINEERING	43.0	47.4	47.8	47.8	48.0	48.0	48.0
SCIENCE, AERONAUTICS AND TECHNOLOGY	**6,527.9**	**7,066.9**	**7,191.7**	**8,079.8**	**8,812.9**	**9,193.9**	**9,552.0**
SPACE SCIENCE	2,524.1	2,624.7	2,786.4	3,144.2	3,560.5	3,897.5	4,008.1
BIOLOGICAL & PHYSICAL RESEARCH	340.3	378.8	360.9	380.7	402.6	405.6	419.4
EARTH SCIENCE	1,690.3	1,716.2	1,515.0	1,587.4	1,571.0	1,572.9	1,578.7
AEROSPACE TECHNOLOGY	1,834.4	2,214.5	2,375.7	2,823.8	3,135.1	3,174.2	3,402.1
ACADEMIC PROGRAMS	138.8	132.7	153.7	143.7	143.7	143.7	143.7
INSPECTOR GENERAL	**20.0**	**22.9**	**23.7**	**24.6**	**25.5**	**26.5**	**27.4**
TOTAL	**13,601.8**	**14,253.2**	**14,511.4**	**14,985.4**	**15,383.4**	**15,659.4**	**16,073.4**

*FY 2000 and FY 2001 restructured to reflect new FY 2002 Full Cost Structure

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

GENERAL STATEMENT

GOAL STATEMENT

The Human Space Flight program comprises NASA's Human Exploration and Development of Space (HEDS) Enterprise, which has as its ultimate mission to open the space frontier by exploring, using and enabling the development of space. Our current programs provide safe, assured transportation to and from space for people and payloads, and develop and operate habitable space facilities in order to enhance scientific knowledge, support technology development, and enable commercial activity. The five strategic goals of the HEDS Enterprise and the Human Space Flight program are the following:

- Expand the Space Frontier
- Enable humans to live and work permanently in space
- Enable the commercial development of Space
- Share the experience and benefits of discovery

In FY 2000 and FY 2001, the Human Space Flight (HSF) account provided only for the *direct* funding of human space flight activities. Space operations services had been funded within the Science, Aeronautics and Technology (SAT) account; and Safety, mission assurance and engineering had been funded within the Mission Support account. Beginning in FY 2002, other-than-direct costs (which includes Research and Program Management and non-programmatic Construction of Facilities) will be allocated to either the HSF or the SAT account based on the number of full time equivalent people, and there will no longer be a Mission Support account.

In FY 2002, the human space flight (HSF) appropriation provides funding for: HSF activities; space operations services; Safety, mission assurance and engineering activities supporting the Agency; and for other-than-direct costs associated with these activities. The HSF activities include development and operations of the Space Station, the Space Station research program, and operation of the Space Shuttle. This includes development of contingency capabilities for the Space Station, high priority investments to improve the safety of the Space Shuttle, and required construction projects in direct support of Space Station and Space Shuttle programs. This appropriation also provides for salaries and related expenses (including travel); design, repair, rehabilitation, and modification of facilities and construction of new facilities; maintenance, and operation of facilities; and other operations activities supporting human space flight programs; and space operations, safety, mission assurance and engineering activities that support the Agency.

STRATEGY FOR ACHIEVING GOALS

In Human Space Flight, we are committed to ensuring effective, efficient and safe transportation of people and payloads to and from space. Our first priority is to fly safely. This requires constant vigilance from the entire Shuttle community, as well as making appropriate investments to reduce risks and increase the safety of the Space Shuttle. In addition, we are actively probing our processes in order to reduce operational costs, improve performance on development projects and to selectively enhance capabilities to meet customer needs.

As we expand our capabilities for allowing humans to live and work continuously in space, we have transitioned our research from the Shuttle-borne Spacelab, to the conduct of joint space activities with Russia aboard the Mir, and now in FY 2001 and beyond to the International Space Station.

Human Space Flight, through the utilization of Space Shuttle and Space Station, provides the capabilities to enable the advancement of scientific knowledge leading to new discoveries, technologies, and materials that will benefit future space exploration and development, as well as life on Earth. In meeting these capabilities, we will ensure that our workforce, our most important resource, will have management support to meet operational and future program requirements through career development training and employee recognition programs.

Recognizing the national benefits of past and future space activities, we will work diligently to maximize the Human Space Flight program's contribution to the national community. We contribute science and engineering educational opportunities for our youth, support collaborative relationships with industry, and improve the nation's quality of life by making advanced technology, directly and through "spinoffs", available to the private sector.

Our implementing strategies for achieving Human Space Flight goals are:

- Engage NASA's customers in setting HEDS goals, objectives, and priorities;
- Ensure that safety and health are inherent in all that we undertake;
- Focus on research and development, and invest in breakthrough technologies;
- Privatize and commercialize operational activities;
- Employ open, competitive processes for selecting research projects;
- Promote synergy with other Enterprises and cooperation and engagement with organizations and customer communities outside of NASA;
- Promote synergy between fundamental research disciplines and mission-oriented research within HEDS and with other Enterprises; and
- The HEDS Enterprise must forge partnerships and customer engagement alliances across a broad spectrum, including academia, industry (aerospace and non-aerospace), other NASA Enterprises, International space agencies and organizations, other U.S. Government agencies, and non-profit and non-governmental organizations.

Human space flight achievements in exploration and development of space have paved the way for enhancing our nation's leadership in expanding the human presence in space. The necessity to fly safely and the requirement to satisfy payload customer needs, while striving to reduce operations costs will be the dominant programmatic thrusts throughout the next decade. Our success in achieving Human Space Flight goals and objectives will play a central role in leading our Nation towards realizing the boundless potential for humankind, of the exploration and development of space.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 2000 OPLAN 01/18/01	FY 2001 OPLAN 03/01/01	FY 2002 PRES BUDGET
	(Thousands of Dollars)		
HUMAN SPACE FLIGHT	**5,487.9**	**5,450.8**	**7,296.0**
SPACE STATION	2,323.1	2,112.8	2,087.4
SPACE SHUTTLE	2,999.7	3,118.8	3,283.8
*PAYLOAD UTILIZATION AND OPERATIONS	165.1	--	--
PAYLOAD AND ELV SUPPORT	--	90.0	91.3
**INVESTMENTS AND SUPPORT	--	129.2	1,303.5
***SPACE OPERATIONS	[490.0]	[521.7]	482.2
****SAFETY, MISSION ASSURANCE AND ENGINEERING	[43.0]	[47.4]	47.8

** In FY 2001, Payload Utilization and Operations was divided into tow new budget lines - Paylaod and ELV Support and Investments and Support*
*** In FY 2002, Investments and Support includes other-than-direct costs for Human Space Flight which were previously included in the Mission Support appropriation account.*
**** In FY 2000, Space Operations was included in the Science, Aeronautics and Technology Appropriation (as Mission Communication Services) and Mission Support Appropriation (as Space Communication Services). In FY 2001, Space Operations was included in the Science, Aeronautics and Technology appropriation*
*****In FY 2000 and FY 2001, SMA&E were included in the Mission Support Appropriation*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

HUMAN SPACE FLIGHT
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses, not otherwise provided for, in the conduct and support of human space flight research and development activities, including research, development, operations, *support* and services; maintenance; construction of facilities including *repair, rehabilitation*, revitalization and modification of *real and personal property*, facilities, construction of new facilities and additions to existing facilities, facility planning and design, *environmental compliance and restoration*, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; *program management; personnel and related costs, including uniforms or allowances therefor, as authorized by U.S.C. 5901-5902; travel expenses*; purchase and hire of passenger motor vehicles*; not to exceed $20,000 for official reception and representation expenses*; and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, [$5,462,900,000] *$7,295,500,000*, to remain available until September 30, [2002] *2003, of which amounts as determined by the Administrator for salaries and benefits; training, travel and awards; facility and related costs; information technology services; science, engineering, fabricating and testing services; and other administrative services may be transferred to the Science, Aeronautics and Technology account in accordance with section 312(b) of the National Aeronautics and Space Act of 1958, as amended by Public Law 106-377: Provided, That the authorized funding level for the International Space Station through fiscal year 2006 shall not exceed $8,197,300,000 except in amounts equal to budget reductions in other Human Space Flight programs.*

(Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2001, as enacted by section 1(a)(1) of P.L. 106.377.)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

HUMAN SPACE FLIGHT

REIMBURSABLE SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 2000 OPLAN 01/18/01	FY 2001 OPLAN 03/01/01	FY 2002 PRES BUDGET
	(Thousands of Dollars)		
HUMAN SPACE FLIGHT	**164.2**	**162.7**	**264.6**
SPACE STATION	0.1	0.1	0.1
SPACE SHUTTLE	22.0	5.3	5.5
PAYLOAD UTILIZATION AND OPERATIONS	142.1	--	--
PAYLOAD AND ELV SUPPORT	--	9.6	0.6
INVESTMENTS AND SUPPORT	--	147.7	194.2
*SPACE OPERATIONS	[64.4]	[65.4]	63.9
**SAFETY, MISSION ASSURANCE AND ENGINEERING	--	--	0.3

** In FY 2000, Space Operations was included in the Science, Aeronautics and Technology Appropriation (as Mission Communication Services) and Mission Support Appropriation (as Space Communication Services). In FY 2001, Space Operations was included in the Science, Aeronautics and Technology appropriation*
*** In FY 2000 and FY 2001, SMA&E were included in the Mission Support Appropriation*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES

DISTRIBUTION OF HUMAN SPACE FLIGHT BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Glenn Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Space Station	2000	2,323,100	1,681,300	123,600	390,100	0	55,500	2,600	2,500	52,000	700	9,800	5,000
	2001	2,112,841	1,502,542	109,648	309,927	0	72,647	6,135	3,995	73,705	3,375	13,500	17,367
	2002	2,087,400	1,650,500	109,300	196,200	0	52,000	0	100	54,500	2,700	2,000	20,100
Space Shuttle	2000	2,999,700	1,666,200	176,400	1,000,000	38,400	6,600	4,800	200	0	0	0	107,100
	2001	3,118,823	1,863,623	161,500	1,021,200	38,700	1,700	4,800	0	0	8,900	0	18,400
	2002	3,283,800	2,072,800	184,100	954,300	47,000	0	4,800	0	0	2,900	0	17,900
Payload and Utilization Operations	2000	165,100	27,171	77,460	44,779	1,586	960	0	900	489	9,900	635	1,220
	2001	0	0	0	0	0	0	0	0	0	0	0	0
	2002	0	0	0	0	0	0	0	0	0	0	0	0
Paylaod and ELV Support	2000	0	0	0	0	0	0	0	0	0	0	0	0
	2001	90,002	1,300	74,502	3,300	0	0	0	0	0	10,900	0	0
	2002	91,300	1,300	75,174	3,426	0	0	0	0	0	11,400	0	0
Investments and Support	2000	0	0	0	0	0	0	0	0	0	0	0	0
	2001	129,214	33,170	11,750	38,438	20,101	100	0	650	1,800	3,005	850	19,350
	2002	1,303,500	408,306	279,055	259,627	52,742	16,846	13,865	10,520	55,742	57,430	11,357	138,010
Space Operations	2000	0	0	0	0	0	0	0	0	0	0	0	0
	2001	0	0	0	0	0	0	0	0	0	0	0	0
	2002	482,200	139,000	69,000	9,000	0	0	13,000	0	7,300	109,300	129,400	6,200
Safety, Mission Assurance and Engineering	2000	0	0	0	0	0	0	0	0	0	0	0	0
	2001	0	0	0	0	0	0	0	0	0	0	0	0
	2002	47,800	8,645	550	3,700	315	1,245	900	6,185	2,035	12,690	7,705	3,830
TOTAL HUMAN SPACE FLIGHT	2000	5,487,900	3,374,671	377,460	1,434,879	39,986	63,060	7,400	3,600	52,489	10,600	10,435	113,320
	2001	5,450,880	3,400,635	357,400	1,372,865	58,801	74,447	10,935	4,645	75,505	26,180	14,350	55,117
	2002	7,296,000	4,280,551	717,179	1,426,253	100,057	70,091	32,565	16,805	119,577	196,420	150,462	186,040

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE STATION**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OP PLAN REVISED	FY 2001 OP PLAN REVISED	FY 2002* PRES BUDGET	Page Number
	(Thousands of Dollars)			
Vehicle	950,100	716,926		HSF 1-5
Operations Capability	703,600	824,682		HSF 1-16
[Construction of Facilities included]	[56]	[--]		
Research	394,400	457,391		HSF 1-24
[Construction of Facilities included]	[3,000]	[--]		
Russian Program Assurance	200,000	24,040		HSF 1-45
[Construction of Facilities included]	[1,000]	[--]		
Crew Return Vehicle	75,000	89,802		HSF 1-47
Total	2,323,100	2,112,841	2,087,400	

Distribution of Program Amount by Installation			(Preliminary)
Johnson Space Center	1,681,300	1,502,542	1,650,500
Kennedy Space Center	123,600	109,648	109,300
Marshall Space Flight Center	390,100	309,927	196,200
Ames Research Center	55,500	72,647	52,000
Langley Research Center	2,500	3,995	100
Glenn Research Center	52,000	73,705	54,500
Goddard Space Flight Center	700	3,375	2,700
Dryden Flight Research Center	2,600	6,135	
Jet Propulsion Laboratory	9,800	13,500	2,000
Headquarters	5,000	17,367	20,100
Total	2,323,100	2,112,841	2,087,400

* FY 2002 funding is currently under review and allocations to Vehicle, Operations, Research, RPA, CRV and final center distributions will be determined as part of program assessments. Any reserves identified as part of the assessments will be managed and dispositioned by the Office of Space Flight headquarters management team.

PROGRAM GOALS

The goal of the International Space Station (ISS) is to establish a long-duration habitable residence and laboratory for science and research and permanently deploy a crew to this facility. The ISS will vastly expand the human experience in living and working in space, encourage and enable commercial development of space, and provide a capability to perform unique, long duration, space-based research in cell and developmental biology, plant biology, human physiology, fluid physics, combustion science, materials science and fundamental physics. ISS will also provide a unique platform for making observations of the Earth's surface and atmosphere, the sun, and other astronomical objects. The experience and dramatic results obtained from the use of the ISS will guide the future direction of the Human Exploration and Development of Space Enterprise, one of NASA's key strategic areas. The International Space Station is critical to NASA's ability to fulfill its mission to explore, use, and enable the development of space for human enterprise.

STRATEGY FOR ACHIEVING GOALS

The International Space Station (ISS) is an international laboratory in low Earth orbit on which American, Russian, Canadian, European, and Japanese astronauts will conduct unique scientific and technological investigations in a microgravity environment. The goal of the Station is to support activities requiring the unique attributes of humans in space and establish a permanent human presence in Earth orbit. The proposed budget provides funding for the continued development of the vehicle and its research components and for current operations, assembly and utilization of the station. With several assembly missions successfully completed, the budget includes funding to keep subsequent assembly missions on schedule through U.S. Core Station Complete, currently planned for late 2003 – early 2004, and for early research commensurate with the buildup of on-orbit utilization capabilities and resources.

Extensive coordination with the user community is well underway, and payload facilities development and research and technology activities are coordinated with the Office of Biological and Physical Research (OBPR), the Office of Earth Science (OES) and the Office of Space Science (OSS). OBPR has administrative responsibility for the ISS Research program starting in FY 2000, responsibility for budget execution in FY 2002, and will gain budget formulation responsibility starting in FY 2003.

The ISS represents an unprecedented level of international cooperation. Space Station Partnership agencies include NASA, the Russian Aviation and Space Agency (Rosaviakosmos), the Canadian Space Agency (CSA), the European Space Agency (ESA), and the National Space Development Agency of Japan (NASDA). International participation in the program has significantly enhanced the capabilities of the ISS.

Russian contributions to the ISS are significant, and include the Service Module, universal docking module, science power platform, docking compartment, life support module, and research modules. The Service Module provides early sleeping and living quarters for crew members. Russia is also providing logistics resupply and station reboosting capability with Progress vehicles, as well as crew transfers and emergency crew return using the Soyuz vehicle.

Canada's contribution to the ISS is the Mobile Servicing System (MSS) and its associated ground elements. The MSS will provide a second-generation robotic arm similar to the Canadian arm developed for the Shuttle. The MSS consists of the 58-foot long Space Station Remote Manipulator System (SSRMS) that can handle masses up to 220,000 pounds, a Base System, and a 12-foot robotic arm called the Special Purpose Dexterous Manipulator (SPDM) that attaches to the SSRMS. CSA has developed a Space Operations Support Centre, MSS Simulation Facility and Canadian MSS Training Facility.

The National Space Development Agency of Japan (NASDA) will provide the Japanese Experiment Module (JEM), which consists of a number of different components. Those components include the following elements: a Pressurized Module (PM), a pressurized laboratory that provides 77% of the utilization capability of the U.S. laboratory and can accommodate 10 racks; an Exposed Facility (EF) for up to 10 unpressurized experiments; a 32-foot robotic arm used for servicing system components on EF and changing out attached payloads; and an Experiment Logistic Module (ELM) for both pressurized and unpressurized logistics resupply, and the HII Transfer Vehicle (HTV) for ISS logistics resupply.

European Space Agency (ESA) contributions emphasize their role in early and continued utilization of the ISS and augmenting the ISS infrastructure. The ESA contributions include: the Columbus Orbital Facility (COF) with accommodations for 10 standard racks; the Automated Transfer Vehicle (ATV) for ISS logistics resupply, propellant resupply and reboost missions, to be launched by the Ariane 5 launch vehicle: and cooperation on the X-38. ESA has also made separate arrangement with the Russian Aviation and Space Agency for two contributions to the Russian elements: the European Robotic Arm (ERA) on the Russian Science and Power Platform and the Data Management System (DMSR) for the Service Module.

Additionally, there are several bilateral agreements between NASA and other nations such as Italy and Brazil, resulting in a total number of fifteen U.S. international partners. An agreement with ESA provides early research opportunities to them in exchange for provision of research equipment to the U.S. Another agreement with ESA provides the U.S. with Nodes 2 and 3 as an offset for the Shuttle launch for the Columbus Orbital Facility (COF). A similar Agreement in Principle with NASDA provides a Centrifuge, Centrifuge Accommodation Module (CAM), and Life Sciences Glovebox as an offset for the Shuttle launch of the Japanese Experiment Module (JEM). NASA and the Italian Space Agency have an agreement for Italy's provision of three Multi-Purpose Logistics Modules (MPLMs) in exchange for research opportunities. The Brazilian Space Agency (AEB) has become a participant in the U.S. ISS program by helping fulfill a portion of U.S. obligations to the ISS program in exchange for access to the U.S. share of ISS resources.

In FY 1999, successful launches of the first two components of the Station-the FGB control module and the first node were completed in November and December respectively, and the elements were assembled in orbit and activated. A third flight delivering supplies to support the first crews was successfully performed in May 1999. Between January 2000 and January 2001, the Russian Service Module, the Z1 and SO trusses, the control moment gyros, the first photovoltaic array and battery sets, initial thermal radiators, communication equipment, and the U.S. Laboratory were assembled on-orbit. A permanent human presence in space was achieved with the launch of Expedition 1. The first phases of multi-element integrated testing (MEIT) were completed. Crew training, payload processing, hardware element processing, and mission operations were supported. During the remainder of 2001, Expedition 2 will be deployed, and Phase 2 of the station assembly will be completed with the launch of the airlock. Preparations will continue for the start of Phase 3 and the first shuttle mission dedicated to research utilization is expected to be launched in mid-2002.

Russian Program Assurance (RPA) is contained within the Space Station budget and provides funding for contingency activities to address ISS program requirements resulting from delays or shortfalls on the part of Russia in meeting its commitments to the ISS program. Key elements of the RPA program have been the Interim Control Module (ICM), developed by the U.S. Naval Research Laboratory (NRL), and the U.S. Propulsion Module. With the successful launch of the Russian Service Module, and escalating costs for Space Station, including RPA components, NASA reassessed its Space Station priorities and the need for planned RPA hardware. In FY 2000, the ICM was placed in "call-up" mode and stored at NRL. Work on the original Propulsion Module design was terminated, and in FY 2001 funds for the Propulsion Module were redirected to cover cost increases in the baseline program. This left logistics contingency funding and funds for potential procurement of safety-related Russian goods and services in the RPA budget.

Based on recent operational experience, continuing flight software and hardware integration issues, obsolescence issues, and realization that earlier assembly phase cost estimates were low, NASA concluded that the program baseline could not be executed on schedule within approved funding levels. A reassessment of the ISS Program budget baseline was started in FY 2000 and continued into FY 2001. The initial results, based on conservative estimating assumptions, showed a budget shortfall of up to $4 billion over 5 fiscal years. To remain within the Agency's budget marks, NASA redirected funds from remaining high-risk, high-cost hardware development, including the Habitation Module and Crew Return Vehicle (CRV), as well as funds from the RPA budget mentioned above, to ensure that ISS would stay within budget, while assembly continues though U.S. Core Station Complete (deployment of Node 2 on flight 10A). This will allow for the integration of flight hardware being provided by the International Partners. In addition, the ISS Research Program is being realigned to match the on-orbit capability build-up as the program moves toward U.S. Core Complete. NASA will continue to pursue atmospheric testing of the X-38 and is assessing the affordability of completing the space flight test relative to other program priorities. Options for provision of a crew return capability and Habitat capability to support the desired increase in crew size from 3 to 6 will be discussed with the international partners. However, U.S. contributions to such capabilities will be dependent on the availability of funds within the President's five-year budget plan for Human Space Flight, technical risks, and the Administration's confidence in Agency cost estimates.

Over the next several years, the Agency will press ahead with ISS assembly and the integration of the partners' research modules. Research operations on board the ISS have been expanding since they began in FY 2000 and will greatly exceed any previous capabilities for research in space including Skylab, Shuttle, or Mir. During 2001, six pallets will be used in Space Shuttle missions. In FY 2001 and 2002, over 20 major and secondary payloads will be supported, including major hardware for ISS assembly.

NASA will also undertake reforms and develop a plan to ensure that future Space Station costs will remain within the President's FY 2002 Budget runout. Key elements of this plan will: 1) restore cost estimating credibility, including an external review to validate cost estimates and requirements and suggest additional options as needed; 2) transfer Space Station program management reporting from the Johnson Space Center in Texas to NASA Headquarters until a new program management plan is developed and approved; and 3) open future Station hardware and service procurements to innovation and cost saving ideas through competition, including launch services and a Non-Government Organization for Space Station research.

BASIS OF FY 2001 FUNDING REQUIREMENT

SPACE STATION VEHICLE

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Flight hardware	761,200	667,017	
Test, manufacturing and assembly	141,500	47,514	
Transportation support	47,400	2,395	
Total	950,100	716,926	

* FY 2002 funding is currently under review and allocations to Flight Hardware, Test, Manufacturing and Assembly Support, and Transportation will be determined as part of program assessments.

PROGRAM GOALS

Vehicle development of the International Space Station (ISS) provides an on-orbit, habitable laboratory for science and research activities, including flight and test hardware and software, flight demonstrations for risk mitigation, facility construction, Shuttle hardware and integration for assembly and operation of the station, mission planning, and integration of Space Station systems.

STRATEGY FOR ACHIEVING GOALS

Responsibility for providing Space Station elements is shared among the U.S. and our international partners from Russia, Europe, Japan, and Canada. The U.S. elements include nodes, a laboratory module, airlock, truss segments, photovoltaic arrays, three pressurized mating adapters, unpressurized logistics carriers, and a cupola. Various systems are also being developed by the U.S., including thermal control, life support, navigation, command and data handling, power systems, and internal audio/video. The U.S. funded elements also include the Zarya propulsion module provided by a Russian firm under the Boeing prime contract. Zarya was the first ISS element launched to orbit. Other U.S. elements being provided through bilateral agreements include the pressurized logistics modules provided by the Italian Space Agency, Nodes 2 and 3 provided by ESA, and the centrifuge accommodation module (CAM) and centrifuge provided by the Japanese.

Canada, member states of the European Space Agency (ESA), Japan, and Russia are also responsible for providing a number of ISS elements. The Japanese, ESA, and Russia will provide laboratory modules. Canada will provide a remote manipulator system, vital for assembly and maintenance of the station. The Russian Aviation and Space Agency (Rosaviakosmos) is also providing significant ISS infrastructure elements including the Service Module (SM), science power platform, Soyuz crew transfer and emergency crew return vehicle, Progress resupply vehicles, and universal docking modules.

The Boeing Company is the prime contractor for the design and development of U.S. elements of the International Space Station. It also has prime responsibility for integration of all U.S. and International Partner contributions and for assembly of the ISS. At their Huntington Beach site location (formerly McDonnell Douglas), Boeing is developing and building the integrated truss segments that support station elements and house essential systems, including central power distribution, thermal distribution, and attitude control equipment. Other Boeing locations are also supporting the flight hardware build to mitigate capability shortfalls at Huntington Beach. Additionally, major components of the communications and data handling, thermal control, and the guidance, navigation and control subsystems are being developed at Huntington Beach.

U.S. pressurized modules are being developed by Boeing at their Huntsville site location, and by ESA and Japan. The second flight to ISS, successfully conducted in December 1998, deployed Unity, a pressurized node which contains four radial and two axial berthing ports. Attached to the Node were two pressurized mating adapters (PMAs), which serve as docking locations for the delivery of the U.S. Laboratory Module and the Multi-Purpose Pressurized Logistics Module. Under a bilateral agreement, ESA is providing Nodes 2 and 3 and a cupola to the U.S. Node 2 is currently manifested for flight during the first quarter of FY 2004. The Cupola and Node 3 are nominally scheduled after the U.S. Core Complete, and their status is being evaluated as part of the ongoing reassessment activities.

The power truss segments and power system, essential to the Station's housekeeping operations and scientific payloads, are being built by Boeing at their Canoga Park location (formerly Rocketdyne Division, Rockwell International). Four photovoltaic elements, each containing a mast, rotary joint, radiator, arrays, and associated power storage and conditioning elements, comprise the power system. The fourth power array is nominally scheduled after the U.S. Core Complete, and its status is being evaluated as part of the ongoing reassessment activities.

The vehicle program also includes test, manufacturing and assembly support for critical NASA center activities and institutional support. These “in-line” products and services include: test capabilities; the provision of government-furnished equipment (GFE) (including flight crew systems, environment control and life support systems, communications and tracking, and extravehicular activity (EVA) equipment); and engineering analyses. As such, they support the work of the prime contractor, its major subcontractors and NASA system engineering and integration efforts.

Transportation support provides those activities that allow the Space Shuttle to dock with the Space Station. This budget funded the development and procurement of two external Shuttle airlocks, and upgrade of a third airlock to full system capability, which were required for docking the Space Shuttle with the Russian Mir as well as for use with the Space Station. Other items in this budget include: the Shuttle Remote Manipulator System (RMS) and Space Shuttle mission training facility upgrades; development of a UHF communications system and a laser sensor; procurement of an operational space vision system; procurement of three docking mechanisms and Space Station docking rings; EVA/Extravehicular Mobility Units (EMU) services and hardware; and integration costs to provide analyses and model development.

In order to ensure that the Space Station budget remains within the President’s five-year budget plan, funds for U.S. elements after U.S. core complete (flight 10A in the Rev. F assembly sequence) have been redirected to address cost growth in the program. NASA is conducting a program reassessment that will seek to reduce the projected growth in cost estimates. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities.

Schedules and outputs are under review, and will be adjusted as part of the ongoing program reassessment.

SCHEDULE & OUTPUTS

Completed Incremental Design Review (IDR) Performed Stage Integration Reviews (SIR)	A series of incremental, cumulative reviews throughout the design phase to assure that system level requirements are properly implemented in the design, have traceability, and that hardware and software can be integrated to support staged assembly and operation. IDR #1 performed these functions for flights 1A/R through 6A. Subsequently, IDR #2 assessed design progress for flights 1A/R through 7A. IDR#2B assessed the entire Space Station assembly sequence. IDRs have been replaced by Stage Integration Reviews (SIR), a more classical critical design review approach on a stage-by-stage basis which review groupings of flights with assembly hardware and functionality/performance linkages across the stage. • *Performed SIR 1 for flights through 2A (4th Qtr FY 1997)* • *Performed SIR 2 for flights through 4A (1st Qtr FY 1998)* • *Performed SIR 3 for flights through 6A (2nd Qtr FY 1998)* • *Performed SIR 4 for flights through 4R (1st Qtr FY 1999)* • *Performed SIR 5 for flights through UF-2 (4th Qtr. FY 1999)* • *Performed SIR 6 for flights through 11A (2nd Qtr FY 2000)* • Perform SIR 7 for flights through 12A.1 (3rd Qtr FY 2001) • Perform SIR 8 for flights through UF-4 (1st Qtr. FY 2002) • Perform SIR 9 for flights through 10A.1 (2nd Qtr FY 2002)

Prime Development Activity

NOTE: All activities listed are planning milestones, and are not contractual. Flights subject to change during reassessment.

Flight 1A/R: Zarya (FGB Energy Block) (First Element Launch) (Proton Launch Vehicle) Planned (Rev B): November 1997 Revised (Rev D Mod): November 1998 Completed November 1998	Self-powered, active vehicle; provides attitude control through early assembly stages; provides fuel storage capability after the service module is attached; provides rendezvous and docking capability. • Completed factory ground testing of first flight unit (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998) • Completed flight software (slip from 3rd Qtr FY 1997 to 1st Qtr FY1998) • Delivered FGB flight article to Baikanour (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1998) • Installed solar arrays in FGB flight article (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998)

	• Removed Zarya from storage and complete deconservation (1st Qtr FY 1999) • Mated FGB to Launch Vehicle (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999) • On-Orbit checkout, Service Module docking, fuel transfer (slip from 1st Qtr FY 1998 to 1st Qtr FY 1999) • Launch of the Zarya (1st Qtr FY 1999)
Flight 2A: Unity (Node 1), Pressurized Mating Adapters (PMA-1, PMA-2) Planned (Rev B): December 1997 Revised (Rev D Mod): December 1998 Completed December 1998	Initial U.S. pressurized element, launched with PMA-1, PMA-2, and 1stowage rack; PMA-1 provides the interfaces between U.S. and Russian elements; PMA-2 provides a Space Shuttle docking location. • Completed Node STA static flight loads testing (slip from 4th Qtr FY 1997 to 1st Qtr FY 1998) • Completed mating of PMA-1 to Node (1st Qtr FY 1998) • Completed flight 2A Cargo Element Integration and Test (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998) • Completed mating of PMA-2 to Node (3rd Qtr FY 1998) • Space Shuttle Payload Integration and Test (slip from 1st Qtr FY 1998 to1st Qtr FY 1999) • Launch of Unity (flight 2A) (1st Qtr FY 1999)
Flight 2A.1 Logistics Planned (Rev C): December 1998 Revised (Rev D Mod): 3rd Qtr FY 1999 Completed June 1999	Double Spacehab flight for logistics/resupply during early assembly. • Station Cargo Integration Review (SCIR) (2nd Qtr FY 1998) • Flight Operations Review (FOR) (2nd Qtr FY 1999) • Hardware on dock at KSC (2nd Qtr FY 1999) • Begin integration of critical spares into Spacehab Module (2nd Qtr FY1999) • Delivery of Strela Cargo Crane to Integrated Cargo Carrier integration (2nd Qtr FY 1999) • Launch of flight 2A.1 (3rd Qtr FY 1999)

Flight 3A: Z1 Truss Segment, Control Moment Gyros (CMGs), PMA-3, KU-Band Planned (Rev B): July 1998 Revised (Rev D Mod): 1st Qtr FY 2000 Revised (Rev E): 2nd Qtr FY 2000 Revised Target: 3rd Qtr FY 2000 Revised (Rev F): 1st Qtr FY 2001 Completed: October 2000	Z1 Truss allows temporary installation of the P6 photovoltaic module to Node 1 for early U.S. based power; KU-band and CMGs support early science capability; PMA-3 provides a Space Shuttle docking location for the lab installation on flight 5A. • Completed CMG qualification and flight testing (2nd Qtr FY 1998) • Z1 modal and static qualification tests complete (slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • PMA-3 on-dock at KSC (Slip from 4th Qtr FY 1997 to 2nd Qtr FY 1998) • KU-Band antenna on dock at KSC (3rd Qtr FY 1998) • S-Band antenna on dock at KSC (3rd Qtr FY 1998) • Z1 flight unit completed and shipped to KSC (3rd Qtr FY 1998) • Plasma Contactor and DDCU-HP Qualification Testing complete (4th Qtr FY1999) • 3A MEIT complete (2nd Qtr FY 2000) • Complete Z1 final outfitting (3rd Qtr FY 2000) • Launch Flight 3A (1st Qtr FY 2001)
Flight 4A: P6 Truss segment, Photovoltaic Array, Thermal Control System (TCS) Radiators, S-Band Equipment Planned (Rev B): November 1998 Revised (Rev D Mod): 1st Qtr FY 2000 Revised (Rev E): 2nd Qtr FY 2000 Revised Target: 4th Qtr FY 2000 Revised (Rev F): 1st Qtr FY 2001 Completed: November 2000	This flight provides the first U.S. solar power via solar arrays and batteries, cooling capability and S-Band system activation. • Beta Gimbal Assembly to P6 Integration (3rd Qtr FY 1998) • IEA/Long Spacer ready for integration and test (4th Qtr FY 1998) • Z1/P6 on dock KSC for MEIT (4th Qtr FY 1998) • Radiator Qualification Testing complete (2nd Qtr FY 1999) • Solar Arrays on-dock KSC (2nd Qtr FY 1999) • Flight Radiators delivered to P6 Outfitting (1st Qtr FY 2000) • 4A MEIT complete (2nd Qtr FY 2000) • Launch flight 4A (1st Qtr FY 2001)

Flight 5A:
U.S. Laboratory, 5 Lab System Racks
Planned (Rev B): December 1998
Revised (Rev D Mod): 2nd Qtr FY 2000
Revised (Rev E): 3rd Qtr FY 2000
Revised Target: 4th Qtr FY 2000
Revised (Rev F): 2nd Qtr FY 2001
Completed: February 2001

Launch of the U.S. Laboratory Module establishes initial U.S. user capability; launches with 5 system racks pre-integrated; KU-band and CMGs are activated.

- Complete installation of 5A/6A Racks in Lab for testing (3rd Qtr FY 1998)
- Lab on dock at KSC (1st Qtr FY 1999)
- Lab Acceptance Testing Complete (4th Qtr FY 2000)
- Deliver Command and Control and Guidance Navigation and Control Software to Lab (4th Qtr FY 2000)
- Complete 5A MEIT (2nd Qtr FY 2000)
- Launch of flight 5A (2nd Qtr FY 2001)

Flight 5A.1:
MPLM flight module-1, 6 Lab System Racks, 1 Payload Rack
Planned: 2nd Qtr FY 2000
Revised (Rev E): 3rd Qtr FY 2000
Revised Target: 1st Qtr FY 2001
Revised (Rev F): 2nd Quarter FY 2001
Completed: March 2001

Continues the outfitting of the U.S. Lab, with the launch of 6 system racks. This flight also represents the first use of science with the launch of the Human Research Facility (HRF) rack. It is also the first use of the Multi-Purpose Logistics Module (MPLM).

- Complete MPLM Integration and Test (4th Qtr FY 1998)
- MPLM on-dock at KSC (4th Qtr FY 1998)
- Integration of HRF Sub-racks into the HRF rack (4th Qtr FY 1999)
- HRF rack on-dock at KSC (4th Qtr FY 2000)
- Early Ammonia Servicer On-Dock KSC (1st Qtr FY 2001))
- MPLM Rack Installation/Closeout (1st Qtr FY 2001)
- Launch of 5A.1 (2nd Qtr FY 2001)

Flight 6A:
MPLM flight module-2, Canadian Remote Manipulator System, UHF
Planned (Rev B): January 1999
Revised (Rev D Mod): 3rd Qtr FY 2000
Revised (Rev E): 4th Qtr FY 2000
Revised Target: 1st Qtr FY 2001
Revised (Rev F): 3rd Qtr FY 2001

Continues U.S. lab outfitting with delivery of 2 stowage and 2 EXPRESS payload racks; UHF antenna provides space-to-space communication capability for U.S. based EVA; delivers Canadian SSRMS needed to perform assembly operations of later flights.

- SSRMS On-dock KSC (3rd Qtr FY 1999)
- Complete Integration and Test of MPLM FM2 (4th Qtr FY 1999)
- MPLM FM2 On-dock KSC (4th Qtr 1999)
- SSRMS and RWS Software complete (2nd Qtr FY 2000)
- 6A MEIT Complete (2nd Qtr FY 2000)
- MPLM Rack Integration / Closeout (2nd Qtr FY 2001)
- Launch of flight 6A (3rd Qtr FY 2001)

Flight 7A: Airlock, High Pressure Gas Tanks (HPGT) Plan (Rev B): April 1999 Revised (Rev D Mod): 4th Qtr FY 2000 Revised (Rev E): 4th Qtr FY 2000 Revised Target: 2nd Qtr FY 2001 Revised (Rev F): 3rd Qtr FY 2001	Launches the airlock and installs it on orbit. The addition of the airlock permits ISS-based EVA to be performed without loss of environmental consumables such as air. • Completed Airlock Integration/A&CO (2nd Qtr FY 1999) • Airlock System Software Complete (2nd Qtr FY1999) • Element level testing complete (2nd Qtr FY 2001) • Airlock on dock at KSC (4th Qtr FY 2000) • Complete SLP integration (2nd Qtr FY 2001) • Launch flight 7A (3rd Qtr FY 2001)
Flight 7A.1 MPLM, SLP pallet Planned (Rev B): November 1999 Revised (Rev D Mod): 4th Qtr FY 2000 Revised (Rev E): 1st Qtr FY 2001 Revised Target: 2nd Qtr FY 2001 Revised (Rev F): 3rd Qtr FY2001	Logistics and utilization mission delivering resupply/return stowage racks resupply stowage platforms, and two EXPRESS payload racks. This flight will carry critical spares as well as various resupply items. First re-use of MPLM FM-1 • MPLM available from 5A.1 (2nd Qtr FY 2001) • MPLM on-dock at KSC (4th Qtr FY 1998) • MPLM Rack Installation/Closeout (3rd Qtr FY 2000) • Launch of 7A.1 (3rd Qtr FY 2001)
Flight 8A: S0 Truss, Mobile Transporter Plan (Rev B): June 1999 Revised (Rev D Mod): 2nd Qtr FY 2001 Revised (Rev E): 2nd Qtr FY 2001 Revised Target: 3rd Qtr FY 2001 Revised (Rev F): 2nd Qtr FY 2002	S0 is the truss segment that provides attachment and umbilicals between pressurized elements and truss mounted distributed systems/utilities. Mobile Transporter provides SSRMS translation capability along the truss. • Complete S0 flight fabrication, assembly, and outfitting (3rd Qtr FY 1999) • S0 on dock at KSC (3rd Qtr FY 1999) • Complete S0 STA Testing (4th Qtr FY 1999) • Complete Mobile Transporter flight article (4th Qtr FY 1999) • Command and Control Software Complete (3rd Qtr FY 2001) • 8A MEIT Complete (4th Qtr FY 2001) • Launch flight 8A (2nd Qtr FY 2002)

Flight 9A: S1 Truss, CETA Cart Plan (Rev B): September 1999 Revised (Rev D Mod): 3rd Qtr 2001 Revised (Rev E): 4th Qtr FY 2001 Revised Target: 1st Qtr FY 2002 Revised (Rev F): 3rd Qtr FY 2002	S1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss. • Complete second S-band string (4th Qtr FY 1998) • Radiators complete for S1 Integration (2nd Qtr FY 2000) • Complete S1 STA testing (2nd Qtr FY 2000) • Complete S1 flight Outfitting and Acceptance Testing (2nd Qtr FY 2000) • S1 on dock at KSC (1st Qtr FY 2001) • 9A MEIT Complete (4th Qtr FY 2001) • Launch flight 9A (3rd Qtr FY 2002)
Flight 11A: P1 Truss (3 Radiators), TCS, CETA, and UHF Band Communications Plan (Rev B): January 2000 Revised (Rev C): 1st Qtr FY 2001 Revised (Rev E): 4th Qtr FY 2001 Revised Target: 2nd Qtr FY 2002 Revised (Rev F): 1st Qtr FY 2003	P1 truss provides permanent active thermal control capability. Crew and Equipment Translation Aid (CETA) cart provides EVA crew translation capability along the truss. • Radiators complete for P1 Integration (2nd Qtr FY 2000) • P1 on dock at KSC (4th Qtr FY 2000) • Complete P1 flight Acceptance Testing (2nd Qtr FY 2001) • CETA Cart Ready for P1 Integration (2nd Qtr FY 2001) • Pump Module ready for P1 Integration (2nd Qtr FY 2001) • 11A MEIT Complete (4th Qtr FY 2001) • Launch flight 11A (1st Qtr FY 2003)

Non-Prime Development Activity

Non-prime development activities continue in FY 2001 and FY 2002. Schedules and outputs are under review, and will be adjusted as part of the ongoing program reassessment.

Global Positioning System (GPS)	Provides autonomous, real-time determination of Space Station's position, velocity, and attitude. • Delivered GPS Antenna Assembly (4th Qtr FY 1997) • Delivered GPS Receiver/Processor (slip from 3rd Qtr FY 1997 to 2nd Qtr FY 1999)

Extra-Vehicular Activity System	Provides Government Furnished Equipment (GFE), EVA unique tools, and EVA support equipment for the Space Station. Provides EVA development and verification testing. Provides for operation of the WETF/NBL and the maintenance of neutral buoyancy mockups to support Station EVA development activities. • Delivered Crew Equipment Transfer Aid (CETA) Cart proto-flight unit (slip from 1st Qtr FY 1997 to 1st Qtr FY2000) • Delivered EVA Tool Storage Device (ETSD) for CETA Cart (1st Qtr FY 1998) • Delivered ETSD for airlock (1st Qtr FY 1998) • Delivered canisters for the Regenerable CO2 System (3rd Qtr FY 1998) • Delivered 1st Flight Regenerator for the Regenerable CO2 System (3rd Qtr FY 1998) • ORU Transfer Device (OTD) flight unit delivered (1st Qtr FY 1999)
Flight Crew Systems	Provides flight and training hardware and provisions for food and food packaging development; housekeeping management; portable breathing apparatus; restraints and mobility aids; tools, diagnostic equipment and portable illumination kit. • Completed 6A Operations and Personal Equipment CDR (1st Qtr FY 1997) • Delivered Restraints and Mobility Aids (1st Qtr FY 1997) • Completed CDR for portable illumination (2nd Qtr FY 1997) • Completed production of tools and diagnostic flight hardware kit (slip from 1st Qtr FY 1998 to 3rd Qtr FY 1998) • Completed Personal Hygiene Kit PRR Preliminary/Program Requirements Review (2nd Qtr FY 1998) • Delivered Maintenance Workstation Kit, Portable Illumination, and Housekeeping Kit (4th Qtr FY 1998)
Airlock Service And Performance Checkout Unit	Provides flight servicing, performance unit, and certification unit, Russian space suit support hardware interface definition and documentation, test plans and reports, mockups, and thermal analysis. • Delivered Qual hardware to airlock test article (Slip from 2nd Qtr FY 1997 to 2nd Qtr FY 1999) • Final Flight Unit Deliveries (2nd Qtr FY 2000)

ACCOMPLISHMENTS AND PLANS

FY 2000 activities focused on the preparations and launches required for Phase 2/3 assembly of the International Space Station. These activities included:

- Flight 2A.2, which was added to the assembly sequence in early FY 1999, and was then divided into two separate flights (2A.2a and 2A.2b) in order to accomplish the FGB life extension after the Service Module launch was postponed to July 2000. Flight 2A.2 was to include internal and external spares and supplies, as well as station outfitting equipment. The first of the two flights (2A.2a), was remanifested to perform FGB lifetime and maintenance tasks before SM arrival. The second, 2A.2b, was flown after delivery of the SM to perform SM outfitting for the Expedition One crew arrival.

- Flight 2A.2a, STS-101, was launched on May 19, 2000 to ferry supplies required by the Expedition One crew, as well as to replace electronics in the Russian built Zarya module. This flight extended *Zarya's* service life through December 2000.

- Flight 1R (SM): The failure of two successive Proton launches in 1999 (July and October) caused a delay in the Service Module launch date since the SM was to be launched on a Russian Proton rocket. This slipped the launch into Summer 2000, causing NASA to take measures to prolong the life of the orbiting FGB module beyond its original service certification. The SM was launched successfully on July 12, 2000 from Baikonur. The SM provides propulsion capability, living quarters and life support for the early ISS crews. The SM docked with the orbiting ISS on schedule two weeks later (July 25),

- Flight 1P: SM docking was quickly followed by the first Russian progress resupply mission on August 6, 2000.

- Flight 2A.2b (STS-106) launched on September 8, 2000 and delivered supplies and outfitted the SM in preparation for the following assembly mission STS-92 (flight 3A), with the Z1 Truss and PMA-3.

FY 2001 activities to date have established a permanent crew on the ISS, deployed the first U.S. solar array to provide power, and launched and activated the U.S. Lab, including the capability for control and communication.

- Flight 3A: The Z1 truss and PMA-3 were launched on October 11, 2000. The Z1 Truss was attached to the Node 1 zenith location, and the PMA-3 attached to Node 1 nadir.

- The Expedition 1 Crew (Flight 2R) launched on October 31, 2000 from Baikonur with three astronauts (Commander Bill Shepherd, Pilot Yuri Gidzenko and Flight Engineer Sergei Krikalev) aboard a Soyuz module which also serves as the crew return capability for the ISS.

- Flight 2P: The launch of Russian Progress flight 2P on November 16, 2000.

- Flight 4A launched the Integrated Equipment Assembly (IEA), Photovoltaic (PV) Array, Early External Active Thermal Control System (EEATCS), and the P6 truss segment on November 30, 2000. This cargo element completed Integrated Electronic Assembly (IEA) integration in September in preparation for being turned over to the space shuttle integration team in FY 2001.

- Flight 5A, U.S. Lab MEIT was completed in the second quarter of FY 2000. Flight 5A/5A.1 racks have been installed, and remaining Lab testing at KSC was completed in the first quarter of FY 2001. The Lab was successfully launched in February 2001.

- Flight 5A.1, added to the assembly sequence in early FY 1999, is the first use of the Multi-Purpose Logistics Module (MPLM). The MPLM for flight 5A.1 completed its integration and testing and was delivered to KSC. The Human Research Facility (HRF) Rack, which represents the first utilization of the ISS for science/experiments, completed the integration of its Sub-racks and was delivered to KSC in the fourth quarter of FY 2000. The MPLM with the HRF was successfully launched in March 2001.

FY 2001 will see the finish of Phase 2 of the ISS Program. FY 2002 will see the beginning of Phase 3 of the ISS assembly sequence, and the beginning construction of the middle truss on the station's backbone (Z1 Truss) launched the previous year. Two Utilization Flights and one outfitting/logistics flight will enable a broader range of research to be conducted as ISS assembly continues. Activities in preparation for these flights include:

- Flight 6A will complete U.S. Lab outfitting with the first launch of the MPLM "Rafaello". Flight 6A also delivers the robotic arm, which is essential to continued assembly of the ISS. The SSRMS completed MEIT activities in the 2nd Qtr of FY 2000 and has been integrated onto the SLP for launch in the 3rd Quarter FY 2001. . There are two EXPRESS payload racks scheduled to be launched on flight 6A. One of these racks is the first use of an Active Rack Isolation System (ARIS) EXPRESS rack. Both of the EXPRESS racks completed their MEIT activities and were integrated into the MPLM in the 2nd Qtr of FY 2001.

- The sixth U.S. mission planned for FY 2001, Flight 7A, will carry the airlock. Once installed, the airlock will provide the station an independent EVA capability, and will bring to a close Phase 2 of ISS assembly. The airlock was delivered to KSC 4th quarter FY 2000, with a post delivery checkout scheduled in early FY 2001. The airlock is on schedule for flight in 3rd Quarter FY 2001.

Activities in FY 2002 include:

- Major flight hardware launches scheduled for FY 2002 include the truss segments for flights 8A (S0) and 9A (S1).

- Completion of 3 of the 4 Multi-Element Integrated Test (MEIT) conditions for flight elements required for assembly flights 8A through 12A.

- Complete final integration and testing of truss segments P3/P4 and S3/S4 with their solar arrays for construction of the middle truss in FY 2003.

- Demonstration of station-based EVA to support up to 30 EVA's from the U.S. Airlock each year.

- Conduct permanent on-orbit operations, providing an estimated 8,000 hours of ISS crew support to station assembly, operations, and research.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION OPERATIONS CAPABILITY

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Operations capability & construction...	53,700	40,000	
Vehicle operations..	390,500	357,500	
Ground operations..	259,400	427,182	
[Construction of Facilities included]	[56]	[--]	
Total...	703,600	824,682	

* FY 2002 funding is currently under review and allocations to Ops Capability & Construction, Vehicle Ops, and Ground Ops will be determined as part of program assessments.

PROGRAM GOALS

The primary objective of the operations program is to safely and reliably assemble, activate, integrate, and operate the ISS. This requires a significant level of ground support including tactical planning, resource allocations, off-nominal situations planning, detailed manifests, stowage planning, imagery planning, crew and ground controller training, flight procedures and crew activity plan development, visiting vehicle operations plans, ISS logistics and maintenance, flight rules and ground procedure development, and real-time operations support. The years of hardware engineering, manufacturing, and testing leading to the final acceptance and launch of various ISS elements is now in the final stages as transition of the International Space Station (ISS) vehicle program to the operations program is taking place. Planning and procurements, element specific operations and anomaly preparation, and detailed integration of all capabilities and constraints of elements and ground systems are occurring across the partnership to ensure the pieces and people operate as one system. The second major goal is to perform operations in a simplified and affordable manner. This includes NASA's overall integration of distributed operations and integration functions to be performed by each of the international partners in support of their elements.

The first crew was launched to ISS in October 2000, setting in motion a progression of international crews who will permanently inhabit the ISS, beyond the confines of Earth. The logistics of providing the crew with what is needed for them to live and productively work in the isolated and harsh environment of space for 24 hour a day, 365 days per year is now a nominal part of ISS activities. This is the first time since the Skylab era in the 1970’s, and the Shuttle-Mir program, that the U.S. will have an extended human presence in space. Because of its massive size and level of international participation, the ISS assembly period will span half a decade, with ISS infrastructure and logistics deployed over multiple flights from launch vehicles across the globe. Because of the program’s complexity, the Space Station team has done extensive planning for operations of several different ISS vehicle configurations on orbit. Each time an element is added to the current station, the flight characteristics and internal systems change, and the ISS stack on-orbit becomes essentially a different vehicle with different thermal constraints, drag coefficients, and other characteristics. The Space Station Program will draw on the experience derived from Skylab, the Shuttle-Mir program, and that gained from operating the Space Shuttle for nearly two decades to address the unique circumstances of building and operating an ever changing ISS vehicle. With each successive docking of an ascent vehicle to the ISS and the transfer of its contents to the ISS, and with each increment of operations, the Program will evaluate its methods and lessons learned to develop even more efficient and effective operations.

STRATEGY FOR ACHIEVING GOALS

The Space Station operations concept emphasizes multi-center and multi-program cooperation and coordination. Operations capability development and construction provides a set of facilities, systems, and capabilities to conduct the operations of the Space Station. For the U.S. segment, the work will primarily be performed at the Kennedy Space Center (KSC) and the Johnson Space Center (JSC). KSC has developed launch site operations capabilities for conducting pre-launch and post-landing ground operations. JSC has developed space systems operation capabilities for conducting training and on-orbit operations control of the Space Station. As ISS partners become operational, their respective ground operations functions are integrated by NASA into the unified command and control architecture, similar to that already in operation for Mission Control Center-Moscow (MCC-M) located in Korolev. The Mission Control Center-Houston (MCC-H) will be the prime site for the planning and execution of integrated system operations of the Space Station. Communication links from both Moscow and Houston will support control activities, using the Tracking and Data Relay Satellite system (TDRSS) system and Russian communication assets.

Beyond ISS specific operations, a consolidated approach between Space Shuttle and Space Station minimizes duplicated effort and costs for command and control, as well as training at JSC. The initial Space Station Training Facility capability is now operational and ISS crews are currently in training. Utilizing lessons learned from Shuttle-Mir, ISS crew training is knowledge and proficiency-based rather than timeline and detailed procedures based, as has been the case for the Shuttle crews.

Space Station vehicle operations provide systems engineering expertise and analysis to sustain the performance and reliability of Space Station hardware and software systems. Sustaining engineering will continue to be consolidated and performed at the Johnson Space Center (JSC). Maintenance and repair costs continue to be minimized by the application of logistics support analysis to the design, resupply/return and spares procurement processes. Flight hardware spares and repair costs will continue to be controlled by establishing a maintenance and repair capability including hardware depots that effectively utilize Kennedy Space Center (KSC) and original equipment manufacturers or other certified industry repair resources.

Flight controllers are being trained to operate the Space Station as a single integrated vehicle, with full systems capability in the training environment. Crewmembers are being trained in the Neutral Buoyancy Lab (NBL) and Space Station Training Facility (SSTF) on systems, operations, and other activities expected during a mission. Part-task and full hardware mockups and simulators are also being used to provide adequate training for the crew prior to flight. Integrated training, consolidation of payload and systems training facilities, and the concept of proficiency-based learning and onboard training will increase the efficiency of the overall training effort.

Engineering operations support provides analysis, systems definition, development, and implementation to ensure that a safe and operationally viable vehicle is delivered and can be maintained. Functions include the following: vehicle design participation and assessment, operations product development, ground facility requirements and test support, ground display and limited applications development, resource planning, crew systems and maintenance, extravehicular activity (EVA), photo/TV training, operations safety assessments, medical operations tasks, mission execution and systems performance assessment, and sustaining engineering.

Cargo integration support provides accurate, timely, and cost effective planning and layout of cargo stowage items, analytical analysis of cargo/transport systems compatibility, and physical integration of cargo items into the transport carriers and on-orbit ISS stowage systems. Launch site processing begins prior to the arrival of the flight hardware at KSC with requirement definition and processing planning. Upon arrival at KSC, the flight hardware will undergo various processes, dependent upon the particular requirements for that processing flow. These processes may include: post delivery inspection/verification, servicing, interface testing, integrated testing, close-outs, weight and center of gravity measurement, and rack/component to carrier installation.

In order to ensure that the Space Station budget remains within the President's five-year budget plan, funds for U.S. elements after U.S. core complete (flight 10A in the Rev. F assembly sequence) have been redirected to address cost growth in the program. NASA is conducting a program reassessment that will seek to reduce the projected growth in cost estimates. Operations is a critical area of this program reassessment. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities.

SCHEDULE & OUTPUTS

Schedule and outputs are under review as part of the program reassessment, and the preliminary information provided below is subject to change.

Space Station Training Facility (SSTF)

The SSTF is the primary facility for integrated space systems operations training and procedures verification. A flight simulation software load is built for every configuration of the ISS. These loads are delivered according to established templates defined by requirements that ensure adequate time to complete crew and flight controller training before the beginning of a mission. These deliveries have supported training for several ISS crew and ground control teams.

Completed:

- SSTF Initial Ready for Training (RFT) for flight 5A (2nd Qtr FY 2000)
- SSTF Final RFT for flight 5A (4th Qtr FY 2000)
- SSTF Initial RFT for Flight 5A.1 (4th Qtr FY 2000)
- SSTF Final RFT for Flight 5A.1 (1st Qtr FY 2000)

- SSTF Initial RFT for flight 6A (2nd Qtr FY 2000)
- SSTF Final RFT for flight 6A (2nd Qtr FY 2000)
- SSTF Initial RFT for flight 7A (2nd Qtr FY 2000)
- SSTF Final RFT for flight 7A (2nd Qtr FY 2001)
- SSTF Initial RFT for flight 7A.1 (2nd Qtr FY 2000)

Planned:

- SSTF Final RFT for flight 7A.1 (3rd Qtr FY 2001)
- SSTF Initial RFT for flight 8A (4th Qtr FY 2001)
- SSTF Final RFT for flight 8A (1st Qtr FY 2002)
- All RFT dates for flights beyond 8A are template dates

Mission Control Center (MCC)

This facility provides integrated command and control capabilities and support to real-time increment operations. This facility consists of a Space Shuttle flight control room, an ISS flight control room, a training flight control room, many backroom support rooms and equipment to support all of these activities. Software loads are built to support flights and simulations as required by training and flight support templates. End-to-end testing between MCC-H and MCC-M has been completed and flight support is ongoing with these two centers. Houston (MCC-H) was in a flight-following mode of operations until flight 5A, when MCC-H became the lead center for real-time command and control of the ISS.

- Mission Control Center ready to support use of ICM (Note: requirement deleted upon successful launch of Russian Service Module)
- MCC Post Mariner Delivery (2nd Qtr FY 2000)
- Delivery to support flight 5A ISS Command and Control Capability (1st Qtr FY 2001)
- Complete backup control center (control center development complete) (3rd Qtr FY 2001) MCC Io Delivery in support of 5A (1st Qtr FY 2001)

Baseline Increment Definition And Requirements Document (IDRD)

The IDRD is the ISS Program requirements document that defines all Program requirements for each ISS increment. Release of this document officially initiates increment specific Product and training Development. This typically occurs at 12 months in advance of the increment.

For Planning Period 3	For Planning Period 4	For Planning Period 5	For Planning Period 6
Plan: May 1999	Plan: May 1999	Plan: June 2002	Plan: October 2002
Revised: February 2000	Revised: July 2001		
Actual: August 2000			

Increment Operations Reviews (IOR)

Prior to each mission or the start of an increment a series of reviews are conducted to ensure complete readiness for a flight or increment in all areas. These reviews are held according to a "launch minus" template with the dates driven by major milestones such as final installation of cargo into the Shuttle. These reviews are chaired by Program management.

IOR for Increment 1
Plan: Sept 1999
Revised: February 2000
Actual: February 2000

IOR for Increment 2
Plan: Dec 1999
Revised: March 2000
Actual: August 2000

IOR for Increment 3
Plan: March 2000
Revised: February 2001

IOR for Increment 4
Plan: November 2000
Revised: June 2001

IOR for Increment 5
Plan: November 2001

IOR for Increment 6
Plan: February 2002

IOR for Increment 7
Plan: June 2002

IOR for Increment 8
Plan: October 2002

Certificate of Flight Readiness (CoFR) Reviews

The CoFR process enables assessment and certification of the successful completion of program activities that are required to ensure mission success. This objective is accomplished by ensuring the certification of the safety and operational readiness of the ISS Program hardware/software, facilities, and personnel that support pre-launch activity, launch/return, on-orbit assembly, operations, and utilization.

Flight 2A.2a Reviews
LPRR: March 2000
PRR: March 2000
SORR: March 2000
FRR: April 2000
PFR: June 2000

Flight 2A.2b Reviews
LPRR: July 2000
PRR: August 2000
SORR: August 2000
FRR: August 2000
PFR: December 2000

Flight 4A Reviews
LPRR: October 2000
PRR: November 2000
SORR: November 2000
FRR: November 2000
PFR: December 2000

Flight 5A Reviews
LPRR: November 2000
PRR: December 2000
SORR: January 2000
FRR: February 2000
PFR: February 2000

Flight 6A Reviews
MRR: October 2000
LPRR: March 2001
PRR: March 2001
SORR: March 2001
FRR: April 2001
PFR: May 2001

Flight 7A Reviews
LPRR: April 2001
PRR: April 2001
SORR: April 2001
FRR: May 2001
PFR: May 2001

Flight UF1 Reviews
LPRR: August 2001
PRR: TBD
SORR: September 2001
FRR: September 2001
PFR: October 2001

Flight 8A Reviews
LPRR: November 2001
PRR: TBD
SORR: December 2001
FRR: January 2002
PFR: January 2002

Flight 3A Reviews	Flight 5A.1 Reviews	Flight 7A.1 Reviews	Flight UF2 Reviews
MRR: June 2000	MRR: September 2000	LPRR: May 2001	LPRR: January 2002
LPRR: August 2000	LPRR: January 2001	PRR: TBD	PRR: TBD
PRR: September 2000	PRR: February 2001	SORR: May 2001	SORR: January 2002
SORR: September 2000	SORR: February 2001	FRR: June 2001	FRR: February 2002
FRR: September 2000	FRR: February 2001	PFR: July 2001	PFR: March 2002
PFR: December 2000	PFR: March 2001		

ACCOMPLISHMENTS AND PLANS

FY 2000

During FY 2000, preparation for the initial operation of ISS with the three-person permanent crew was successfully performed. Space Station Operations supported U.S. missions 2A.2a, 2A.2b, and readiness for 3A, and 4A. It supported Russian missions delivering the Service Module and a Progress logistics resupply to ISS. The Service Module (SM) was a major milestone for the ISS in that it contained the life support and crew stations for three crewmembers.

The Zvezda Service Module was launched without a crew aboard and docked with the orbiting ISS by remote control. In addition to early station living quarters, the SM also provides life support, navigation, communications, guidance and propulsion to the new station. Flights 2A.2a and 2A.2b, both logistics flights, were primarily conducting transfers of logistics and supplies to the new space station. The 2A.2a and 2A.2b crews also began orbital checkout and setup of the new living quarters. In addition, a spacewalk was performed to install the Russian Strela crane's telescoping boom.
Expedition 1 crew trained in Russia for 14 additional weeks before launching on a Soyuz. While the Expedition 1 crew was in Russia they participated in three remote training sessions in which they were able to connect back to the Space Station Training Facility (SSTF) located in Houston. This was a first for the Expedition crew to participate in a US training session remotely from Russia. Plans are to continue to use this capability for training future Expedition crews.

Since Shuttle flights average 10 days, the Shuttle crew typically trains up to the launch of the mission. However with ISS missions lasting 3 to 4 months, the Expedition crews continue to train for some objectives in flight. The use of on-board training to stay proficient with critical tasks that they might have to perform during the mission was initiated for the Expedition 1 crew. This training ranges from emergency drills to procedure reviews to computer based training (CBT).

Some Soyuz introduction training for all of the ISS astronauts is conducted at JSC. The Russian Orlan EVA spacesuit has been integrated into the Neutral Buoyancy Lab (NBL) and the US EVA spacesuit has been integrated into the Russian Hydrolab. This gives NASA the capability to train on either spacesuit in the US or Russia.

FY 2001

In FY 2001 the ISS program is conducting the first year of permanently crewed on-orbit operations. It will also be the first year of U.S. leadership of the primary real time ISS vehicle control function. ISS will begin operations with contributions from additional international partners. The Canadian Space Station Remote Manipulator System (SSRMS) will be installed on the ISS, and the program used the MPLM from Italy for the first time.

Flight 3A was launched with the Space Shuttle Discovery in October 2000, and included the Integrated Truss Structure Z1, PMA-3, the KU-band communications system, and Control Moment Gyros (CMG's). The first ISS crew, designated Expedition 1, was launched with a Russian Soyuz spacecraft. This began the commencement of permanent human presence in space aboard the ISS. This crew remained aboard the ISS for 4 months before departing. The Soyuz will remain attached to the ISS to provide assured crew return capability without the Shuttle present. Flight 4A, launched with the Space Shuttle Endeavor, delivered the Integrated Truss Structure element P6, a photovoltaic module and two radiators, thereby providing U.S. power and cooling. The S-band communications system will be activated for voice and telemetry.

As each flight adds to the complexity of the Station, the need for analysis of growing maintenance requirements becomes more relevant. In the first quarter of 2000, techniques were developed to predict maintenance backlog and resource requirements for space station. Thus far, 14 planned critical spares have been delivered to orbit, ensuring that the on-board crew has the ability to immediately repair failures that would halt assembly, threaten Station survival or cause the crew to evacuate. In addition, the crew has completed 78 identified maintenance tasks, which included 36 preventive maintenance tasks and 42 corrective maintenance tasks. One such task, completed on Flight 4A, was a design modification to the Solar Array Wing. A robotic interface (Power Data Grapple Fixture) was added to allow a swapout in the event the Wing failed to deploy.

Flight 5A, launched with the Atlantis, carried Destiny, the U.S. Laboratory Module. Destiny was launched with 5 system racks installed. With the delivery of the electronics in the lab, the CMG's are activated, providing electrically powered attitude control. Flight 5A.1, launched aboard the Discovery, ferried the Expedition 2 crew to the station and returned the first crew to earth. It also carried Leonardo, the first Multi-Purpose Logistics Module (MPLM), with equipment racks to outfit the lab module, and the first research rack, HRF #1. A Russian Soyuz rocket will launch the Docking Compartment (DC-1). This will provide additional egress, an ingress location for Russian-based spacewalks, and a Soyuz docking port. Flight 6A, launched aboard the Shuttle Endeavor, will carry Raffaello, the second Italian-built Multi-Purpose Logistics Module (MPLM), including six systems and two storage racks for the U.S. Lab. Also aboard is the UHF antenna to provide space-to-space communications capability for U.S.-based spacewalks, and the Canadian SSRMS (station mechanical arm) required to perform assembly operations on later flights. Flight 7A, launched aboard the Atlantis, will deliver the Joint Airlock and the High Pressure Gas Assembly. The former will provide station-based extravehicular capability for both U.S. and Russian spacesuits, while the latter will support spacewalk operations and augment the Zvezda Service Module gas resupply system. The addition of this hardware completes Phase 2 of the ISS, indicating that it has achieved a certain degree of self-sufficiency and capability without the presence of an orbiter. Flight 7A.1 will use the Shuttle Endeavor to ferry the third resident crew to the station. It would also carry an Italian-built MPLM module containing U.S. stowage racks and International Standard Payload Racks (ISPR's). The second U.S. built spacewalkers' crane will be attached to the exterior of the station.

Expedition 3 has two more training trips to Russia this year and two more trips in the US with their launch in the summer. Expedition 4 is also training in preparation for launch. Last year Expedition crews as well as Shuttle crews were trained at JSC and in Russia. This year Russian Cosmonauts that fly the Soyuz to ISS will train at JSC. The next Expedition crew scheduled to launch on a Soyuz will be the Expedition 5 crew.

Training for Expedition crews 5, 6 and 7 will continue in FY 2001 and is scheduled to be completed in FY 2002. The training template suggests that the crews for Expeditions 8-11 will begin in FY 2001. Space Station Operations will provide real time support to flights 5A.1, 6A, 7A, and 7A.1. IDRD's for planning periods in 2002 and 2003 will be baselined.

The Space Station Training Facility (SSTF) became available to support the ISS mission near real time. Any problems or procedures that the Mission Control Center (MCC) would like to run before having the ISS Expedition crew execute them on orbit can now be performed in the SSTF. Space Station Training Facility will support crew and flight controller training through 8A in FY 2001. MCC-H will support through 5A. Primary real-time ISS vehicle control responsibility was transferred from MCC-M to MCC-H with Flight 5A. MCC-H software loads will be delivered for flights up to UF-2. Standalone Payload Training Capability (PTC) was operational for flight 5A.1; the integrated PTC will be ready for flight UF-3.

FY 2002

FY 2002 will signify the beginning of Phase 3 of the Station Program. For much of 2002 the station will be supplied with experiment and logistics racks, including the first deployable cargo carrier. The major framework of the station will begin to take shape and the arrival of the next three rotating Expedition crews is also planned.

UF-1, the first utilization flight, will be delivered by Atlantis, and will include an MPLM and PV Module Batteries. The MPLM will contain experiment racks for the U.S. Lab and two storage racks. Beginning with Flight 8A the crew will install the Integrated Truss Structure S0 and the Mobile Transporter. The S0 is the center segment of the 91-meter (300-foot) station truss and attaches to the U.S. Lab. The Mobile Transporter will create a movable base for the station's Canadian mechanical arm, allowing it to travel along the station truss after delivery of the Mobile Base System, or MBS. The launch of 4S (Soyuz) will bring the Expedition 5 crew aboard and will be the first return of a departing Expedition crew aboard a Soyuz. The second utilization flight, UF2, provides more experiment racks and three stowage and resupply racks to the station. The Mobile Base System, once installed on the Mobile Transporter, will complete the Canadian Mobile Servicing System, or MSS.

The first starboard truss segment, S1, arrives on Flight 9A. As part of the integrated truss structure, it will house batteries, computers, radiators, antennas, and gyroscopes. 9A will also bring aboard cooling radiators, backup S-band communications, and the Crew and Equipment Translation Aid (CETA) cart that will enable EVA crew to move along the truss with their equipment. The Utilization and Logistics Flight (ULF1) is scheduled to launch in June 2002 and will mark the first flight of a deployable cargo carrier known as the External Stowage Platform (ESP2). ESP2 will be deployed from the Space Shuttle by the Space Station Remote Manipulator System (robotic arm) and attach to the air lock of the ISS as a permanent spare parts stowage facility – a sort of depot in space. It will include a cargo pallet specially outfitted with release mechanisms to permit ORU removal and replacement and cable systems to provide power directly from the ISS to individual payloads. The Expedition 6 crew will also arrive on ULF1.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION RESEARCH

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Research Projects..	246,200	300,353	
Utilization Support...	148,200	157,038	
[Construction of Facilities included]	[3,000]	[--]	
Total..	394,400	457,391	

* FY 2002 funding is currently under review and allocations to Research Projects and Utilization Support will be determined as part of program assessments.

PROGRAM GOALS

NASA will utilize the ISS as an interactive laboratory in space to advance scientific, exploration, engineering and commercial activities. As a microgravity laboratory, the ISS will be used to advance fundamental scientific knowledge, foster new scientific discoveries for the benefit of the U. S., and accelerate the rate at which it develops beneficial applications derived from long-term, space-based research. The ISS will be the world's premier facility for studying the role of gravity on biological, physical and chemical systems. The program will deliver the capability to perform unique, long-duration, space-based research in molecular, cellular, comparative, and developmental biology, human physiology, biotechnology, fluid physics, combustion science, materials science and fundamental physics. The experience and knowledge gained from long-duration human presence on the ISS will help us learn how to more safely and effectively live and work in space. ISS will also provide a unique platform for making observations of the Earth's surface and atmosphere, the sun and other astronomical objects, as well as the space environment and its effects on new spacecraft technologies.

NASA is in the process of restructuring the research program to better align it with the on-orbit capabilities and fiscal resources available. The results of this review, with preliminary results completed in the next few months, will require adjustments to the research planning. This restructuring activity will be completed no later than September, 2001prior to submission of the FY 2003 budget request to the Office of Management and Budget. In order to ensure that the Space Station budget remains within the President's five-year budget plan, funds for U.S. elements after U.S. core complete (flight 10A in the Rev. F assembly sequence) have been redirected to address cost growth in the program. In addition, funding for U.S. research equipment and associated support will be aligned with the assembly build-up. NASA is conducting a program reassessment that will seek to reduce the projected growth in cost estimates. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities. The following narrative highlights issues and areas which will be prioritized and restructured over the next few months.

STRATEGY FOR ACHIEVING GOALS

The strategy for obtaining the program's goals for ISS is threefold: 1) complete and deploy the core ISS research facilities and the supporting infrastructure; 2) conduct research during the assembly in a diversified set of disciplines; and 3) facilitate commercial utilization of the space environment.

1) *Complete and deploy the core ISS research facilities and the supporting infrastructure.*

The core of the ISS research program will be the first 10 racks scheduled for deployment including the Human Research Facility Rack 1 and 2, six Express Racks, the Microgravity Sciences Glovebox, and the Window Observational Research Facility.

The remaining major research facilities including the Gravitational Biology Facility, Centrifuge Facility, Materials Science Research Facility, Fluids and Combustion Facility, Biotechnology Facility, and the Low Temperature Microgravity Physics Facility will be built on a priority basis, as fiscal resources are available. The research program hardware will emphasize automation, remote monitoring, real-time feedback, telemanagement and ground commands to maximize utilization opportunities.

NASA is developing the Expedite the Processing of Experiments to Space Station (EXPRESS) racks for the pressurized laboratories, and EXPRESS pallets for the unpressurized environment of the Station to increase the research return from the ISS by raising the overall numbers of payloads through allowing access to the station for investigations and payloads at a sub-rack and sub-pallet level.

The common-use Laboratory Support Equipment such as the Microgravity Science Glovebox, the Life Science Glovebox, the Minus Eighty degree Laboratory Freezer for the ISS (MELFI), and the Cryofreezer will allow quick, simple experiments to be conducted aboard the ISS, as well as support experiments in the other facilities and EXPRESS Racks.

Research Facility Descriptions

These research facilities will be reviewed during the budget restructuring activity and prioritized as part of the program reassessment.

Biomedical research facilities and activities include the Human Research Facility (HRF), the Crew Health Care Subsystem (CHeCS) and associated payload development. The HRF provides an on-orbit laboratory that will enable life science researchers to study and evaluate the physiological, behavioral, and chemical changes in human beings induced by space flight. The HRF consists of two racks, and associated payload equipment. Research performed with the HRF will provide data relevant to long-term adaptation to the space flight environment. Many capabilities developed for the HRF have Earth-based application. HRF hardware will enable the standardized, systematic collection of data from the ISS crewmembers, to conduct basic and applied human research and technology experiments.

In addition to the biomedical research that will be conducted using the HRF, NASA's biomedical activities aboard the ISS will include the suite of hardware necessary to protect crew health. CHeCS will support medical care requirements for the ISS crew following deployment of the U.S. Laboratory module. CheCS hardware will provide inflight capabilities for ambulatory and emergency medical care. It will support monitoring of medically necessary environmental parameters, along with capabilities for counteracting the adverse physiological effects of long-duration space flight. Hardware commonality between CHeCS and the HRF and the synergy between the two programs will result in maximum research efficiency and cost savings.

Supporting the Fundamental Space Biology discipline, the Gravitational Biology Facility includes two Habitat Holding Racks, a Centrifuge Rotor, Life Sciences Glovebox, and two service system racks. This suite of equipment, and associated payloads comprise the world's first complete gravitational biology laboratory in space to provide basic tools to conduct physiological, developmental biology and genetic research on the whole organism and at the cellular level. When completed it will support the growth and development of a variety of biological specimens, including animal and plant cells and tissues, aquatic organisms, insects, higher plants, and rodents. The Gravitational Biology Facility will support specimen sampling and storage as well as limited analysis activities. A modular design will accommodate the incremental development of experiment capabilities in a manner consistent with evolving ground and flight science needs of the international research community.

A centrifuge measuring 2.5 meters in diameter will provide artificial gravity, generating forces ranging from 0.01 g to 2.0 g (i.e., from 1/100 to twice the gravity on Earth). Specially developed "holding racks" in the laboratory will provide electrical power and cooling to plant and animal habitats. Habitats in the holding racks will provide food, water, light, air and waste management as well as humidity and temperature control for a variety of specimens-rats and mice, insects, plants, small aquatic organisms, one-celled organisms, and cell cultures. Under the NASA-NASDA Agreement in Principle, National Space Development Agency of Japan (NASDA) will provide the Centrifuge Rotor, Life Sciences Glovebox and the Centrifuge Accommodation Module.

Microgravity Research flight hardware development includes the Material Science Research Facility, Fluids and Combustion Facility, the Space Acceleration Measurement System (SAMS II) and the Microgravity Acceleration Measurement System (MAMS), Structural Biology Test hardware, Microgravity Sciences Glovebox, Biotechnology Facility, Low-Temperature Microgravity Physics Facility, and associated payload development.

The Space Station Materials Science Research Facility (MSRF) consists of three autonomous racks that will be used to study underlying principles necessary to predict the relationships of synthesis and processing of materials to their resulting structures and properties. The research goals of these studies are to establish and improve quantitative and predictive relationships between structure, processing, and properties of metals and alloys, polymers, electronics and photonics, ceramics and glasses, and nano-structured and bio-materials, as well as further the development of materials for human radiation shielding in long-term occupation of space. Many industrial applications from this research apply to metals, microelectronics, metalography, ceramics, agriculture, mining, and forestry. Cooperative efforts are underway with the international science community that will assist in the development of some discipline-specific furnace inserts for use by the U.S. science community, thus leveraging the hardware development investments undertaken by NASA. The initial configuration of the first rack will contain the Space Product Development Experiment Module (SPDEM) and a European Space Agency (ESA)-developed Experiment Module that can process, and accommodate the exchange of multiple furnace inserts for specific classes of U.S. investigations.. After completion of the commercial investigation, the commercial Experiment Module will be replaced on-orbit with additional NASA-developed Experiment

Modules. The studies performed in the MSRF will also support the Office of Industrial Technologies of the Future (IOF) partnerships with eight U.S. industries.

The Fluids and Combustion Facility (FCF) is a modular, multi-user facility that will accommodate sustained, systematic microgravity experimentation in both the fluid physics and combustion science disciplines. The FCF is a three-rack payload consisting of the Fluids Integrated Rack, the Combustion Integrated Rack, and the Systems Accommodation Rack. The first two of these racks, the CIR and FIR, are incrementally deployed to ISS and operated independently. They are then fully integrated into and operated as the FCF System upon arrival of the Systems Accommodation Rack (SAR). Because of the modularity, capability and flexibility of the FCF System, experiments from science disciplines outside of fluids and combustion, as well as commercial and international payloads, can also be supported by the FCF.

The Combustion Integrated Rack houses a combustion chamber designed to accommodate a variety of experiments or modules to conduct multiple experiments within a given class of investigations. It is equipped with ports to allow an array of modular diagnostic systems to view the experiment. This rack supports investigations with the goal of improving our understanding of combustion processes to help us deal better with the problems of pollutants, atmospheric change and global warming, unwanted fires and explosions, and the incineration of hazardous wastes.

The initial experiment module to fly in the (CIR) will be the Multi-User Droplet Combustion Apparatus (MDCA). The objectives of this experiment apparatus are to improve our understanding of how liquid-fuel droplets ignite, spread, and are extinguished under microgravity conditions. It will accommodate four unique investigations with droplets of various sizes that are either deployed or supported by a tether. Its modular approach permits on-orbit changes to these investigations such as using different fuels, droplet-dispensing needles, and droplet tethering mechanisms. The MDCA will also use a variety of diagnostic measuring techniques that will capture the specific data desired by the PI, including radiometry, soot volume fraction, soot pyrometry, soot sampling and particle imagery.

The Fluids Integrated Rack is designed to accommodate several multi-purpose experiment modules that are individually configured with facility-provided and experiment-specific hardware to support each fluids experiment. It supports investigations to better understand the physical principles governing fluids, including how fluids flow under the influence of energy, such as heat or electricity; how particles and gas bubbles suspended in a fluid interact with and change the properties of the fluid; how fluids interact with solid boundaries; and how fluids change phase, either from fluid to solid or from one fluid phase to another.

The first multi-purpose investigation planned for the FIR is the Light Microscopy Module (LMM). This apparatus is a fully remotely controllable on-orbit microscope, allowing a variety of diagnostic measurements and controls of fluids experiments, and other discipline investigations. Initially four experiments are planned which will investigate heat conductance in microgravity to determine the transport process characteristics in a liquid film, and the complementary aspects of the nucleation, growth, structure and properties of colloidal crystals in microgravity. Key diagnostics under development include video microscopy (to observe basic structures), interferometry (to measure vapor bubble thin film thickness), laser tweezers (to manipulate colloidal particles), confocal microscopy (to provide three dimensional visualization of colloidal structures) and spectrophotometry (to measure crystal photonic properties).

The Systems Accommodations Rack provides common support systems such as data/image processing and power distribution for both the combustion and the fluid integrated racks. Once the SAR is deployed, these common functions will be transferred to it, thus allowing for increased science specific real estate on the CIR and FIR and more science throughout. The SAR will also house stand-alone fluids experiments, as well as experiments from other microgravity disciplines, including international investigations.

The Structural Biology Test hardware is composed of a suite of instruments including the Iterative Biological Crystallization (IBC), Crystal Preparation Prime Item (CPPI) and supporting equipment that will meet the requirements imposed by the recent National Research Council report to fund a series of high-profile grants to support microgravity research to produce crystals of macromolecular assemblies with important implications of cutting-edge biology problems. The Structural Biology Test hardware will emphasize automation, monitoring, real-time feedback, telemanagement, and sample recovery (via mounting and cryogenically freezing). The purpose is to increase the sample iteration throughput and enable qualitative processing changes in a microgravity environment on the ISS.

The Microgravity Science Glovebox (MSG) is a rack that allows crew interaction with an experiment, while providing at least one level of containment for potentially hazardous materials. It will allow small-scale research to be carried out in the various fields of materials science, fluid mechanics, combustion, biotechnology, cell science, and acceleration measurement. The rack provides a work volume for placing the experiment, and an airlock mechanism for transferring items into the work volume without compromising the level of containment. It provides power, data, video, and thermal interfaces to the payload within the work volume. This rack is being developed by ESA through a barter agreement.

The Biotechnology Facility (BTF) is the laboratory component of ISS that hosts basic and applied research in cell science. The BTF is a one rack modular design that uses microgravity conditions to achieve unique goals in the engineering of human tissues for research and transplantation, modeling of human disease (cancer), vaccine and drug development, production of biopharmaceuticals, and space cell biology that supports the exploration of space. NASA-developed bioreactors have already produced the first 80-day lung culture, the first normal human intestine culture, and major breakthroughs in the quality of cancer tumor cultures. Two bioreactor flight experiments on Mir cultured tissues over four-month periods. The BTF will support bioreactor research to address the long-duration aspects of this research.

The Low Temperature Microgravity Physics Facility (LTMPF) attached payload will investigate the fundamental behavior of condensed matter without the complications introduced by gravity and perform high-resolution tests in gravitational physics. Primary LTMPF research will study the universal properties of matter at phase transitions, the dynamics of quantum fluids, and test Einstein's theory of relativity. The LTMPF will be a remotely operated payload package attached to the Japanese Exposed Facility of the Station and is expected to improve measurements by a factor of 100 over similar terrestrial tests. This attached payload facility will support research instruments at a temperature between 0.5 and 4 degrees Kelvin and provide up to 6 to 8 months of microgravity operation between reservicing and hardware changeout.

The Window Observational Research Facility (WORF) will be located in the U.S. Laboratory Module at the nadir- (Earth) pointing window location. The WORF is placed in front of the US Laboratory's 20-inch-diameter research-quality window. This is the highest quality optical window ever flown on a crewed spacecraft. The WORF supports optical equipment for environmental monitoring and Earth observations, as well as viewing of rare and transitory surface and atmospheric phenomena. Operation of the rack and sensor payloads will be performed remotely from the ground, or by the crew.

The Stratospheric Gas and Aerosol Experiment (SAGE III) attached payload will measure chemical properties of the Earth's atmosphere between troposphere and the mesosphere. A key aspect of this research will investigate effects of aerosols on ozone depletion in the atmosphere. SAGE III will be attached outside of the Station on an EXPRESS Pallet. The SAGE III instrument will be mounted on an ESA-provided precision-pointing platform.

As noted, significant progress continues to be made in the establishment of international participation in the provision of U.S. research facilities. The Centrifuge, Centrifuge Accommodation Module, and Life Sciences Glovebox development continue under the Implementing Agreement with the NASDA as partial offset for the Shuttle launch of the JEM. The cryogenic freezer racks and the Minus-Eighty Degree Laboratory Freezer (MELFI) and the Microgravity Science Glovebox (MSG) will be provided by the ESA under a March 1997 Memorandum of Understanding. The Brazilian Space Agency (AEB), as a participant in the NASA program, will provide the EXPRESS Pallet and the Technology Experiment Facility under an Implementing Arrangement between the U.S. and Brazilian governments.

Utilization Support Infrastructure

While many of these utilization support capabilities are already in place to support research during the early assembly sequence, they will be reviewed during the budget restructuring activity and future upgrades and expansions will be prioritized as part of the program reassessment.

In addition to the major facility-class payloads, NASA plans to fly smaller, less complex payloads on the ISS which will typically have more focused research objectives and shorter development time cycles and will be easily adapted to a variety of users. An EXPRESS Rack will enable a simple, streamlined and shortened analytical and physical integration process for small payloads by providing standard hardware and software interfaces. The EXPRESS pallet project provides small-attached payloads with a similar streamlined process and hardware and software interfaces. The Brazilian Space Agency is responsible for developing the EXPRESS pallets for NASA.

Laboratory Support Equipment (LSE) is under development to support Life and Microgravity Sciences and other experiments. This equipment includes a digital thermometer, video camera, passive dosimeter, specimen labeling tools, microscopes, small mass measurement device, pH meter, and an incubator. A cryogenic transport freezer and the Minus Eighty-Degree Laboratory Freezer (MELFI) are also being developed to support ISS research activities.

NASA continues to develop a ground infrastructure to support the deployment and operation of the research on the ISS. These capabilities provide the facilities, systems and personnel to support the ISS user community in efficient and responsive user/payload operations. Support is provided for flight and ground capabilities to ensure efficient and complete end-to-end payload operations. NASA and International Partner payload operations are integrated to ensure efficient, compatible use of ISS payload resources. This infrastructure provides pre-flight payload engineering integration, verification and checkout support, payload operations integration, payload training, mission planning, real-time operations support, data processing and distribution and launch site support. Services begin with initial definition of the payload for flight and continue throughout onboard ISS operation and return of experiment's data and equipment to the user. Services include documentation of interfaces and verification requirements, training of ground and flight teams, and development and execution of mission plans to meet the needs of the user community.

The Payload Operations and Integration Center (POIC) is a facility that manages the execution of on-orbit ISS payloads and payload support systems in coordination with the Mission Control Center in Houston (MCC-H), the distributed International Partner Payload Control Centers, Telescience Support Centers and payload-unique facilities. The POIC is established and managed by NASA to provide ISS overall integration of payload planning and coordination of on-orbit payload activity execution. It provides a single point of contact between the MCC-H and all utilization activity. In this capacity, the POIC manages payload resource usage, vehicle support system configuration, space-to-ground communications, and overall payload safety operations. To support operations, the POIC Cadre produces a number of operations products based on payload developer submitted data including: flight rules, payload regulations, payload On-orbit Summaries (operations plans), payload procedures, payload computer displays, training lessons/plans, simulation scripts, payload operations handbook, payload ground command procedures, payload systems manuals, console handbooks, data/video plans, command plans, and data flow plans.

The heart of the POIC capability is the Enhanced Huntsville Operations Support Center (HOSC) System (EHS) software. Under development by Lockheed-Martin, this software package coupled with commercial computing systems provides the capability to build, process and transmit commands to the on-orbit payloads, decommutate and route payload telemetry, uplink, downlink and transfer files, record and store telemetry, store and display payload procedures, and a whole host of other functions required for control center operations.

The external interfaces of the POIC include voice, video and data via the NASA Integrated Services Network (NISN) network to the MCC-H, KSC, White Sands, the Telescience Support Centers (TCS), the International Partner control centers and remote payload investigator home sites (such as universities). Voice and file transfer circuits have been activated to MCC-H, Mission Control Center-Moscow (MCC-M), and the Johnson Space Center and Glenn Research Center TSC's.

Key to the implementation of research aboard the ISS is the ability to control a payload from the researcher's laboratory. To implement this NASA has developed the Telescience Resource Kit (TReK). The TReK is a PC-based, low-cost (approximately $10K) telemetry and command system that will be used by scientists and engineers to monitor and control experiments located on-board the ISS. A TReK system can be located anywhere in the world. This provides a way for scientists and engineers to monitor and control their experiments located in space from their offices and laboratories at home.

In addition to the TReK, NASA is building Telescience Support Centers in strategic locations--Johnson Space Center, Marshall Space Flight Center, Ames Research Center, and Glenn Research Center--to support local operation of EXPRESS Racks and facility-class payloads. These Telescience Support Centers provide significantly more capability for interaction with a rack than does the TReK. The facility operators can manage all functions of their rack, while interacting remotely via TReK with the Principal Investigators, to monitor and control the command and telemetry of the investigation on ISS.

The Payload Planning System (PPS) is a key element of ISS payload planning and execution. It provides unique science operations support and scheduling capabilities not available in the Consolidated Planning System (CPS) employed Johnson Space Center for ISS systems and overall operations integration while still utilizing many core CPS capabilities. Examples of unique PPS capabilities include: flexible schedule adjustment as scientific results are obtained, while remaining within the resource constraints defined by the MCC-H; ability to plan payload operations that allow the payload developer to segment and combine science procedures for both repetitive and unique sequences; and integrated management of ISS resources (power, thermal, bandwidth, crew time, etc.) allocated to payloads.

The Payload Data Library (PDL) is an Oracle-based relational database that provides the prime data collection and storage capability for pre-flight payload integration for the Payload Developers. PDL provides each payload developer with a web-based interface to electronically submit Payload Integration Agreement (PIA) data supporting tactical planning as well as Interface Control Document (ICD) and Payload Data Set submissions that comprise the raw material for flight-specific operations product development.

NASA has developed a distributed approach to verification of ISS interfaces prior to flight through the development and deployment of Payload Rack Checkout Units (PRCU) and Suitcase Test Environments for Payloads (STEP) test tools.

The STEP provides simulation of ISS-to-Payload data system interfaces. It is portable and designed for use at payload development sites, early in the software and data systems design cycles. The STEP allows the developer to test software and communication protocols against a common standard during development in order to optimize design solutions and minimize errors late in the development cycle. This distributed approach to verification testing allows for identification and resolution of most problems prior to sending the payload to Kennedy Space Center for final functional test before flight. In addition to interface verification, STEPs are being utilized for crew training by providing high fidelity ISS data simulation for payload rack training units.

The Payload Test and Checkout System (PTCS) is the ground system at Kennedy Space Center in which final verification for flight is performed. The PRCU simulates all ISS-to-Payload Rack power, data, and fluids interfaces, providing capability for development and verification testing of payload racks at the sites where they are being built and/or integrated. In this test system, final rack and experiment level checkout is performed utilizing actual flight and ground system software and high fidelity ISS Flight Equivalent Units. The PTCS also allows integrated testing of racks with a Payload Operations Integration Facility workstation, identical to what experimenters will see on-orbit, emulating a close loop test.

The Space Station Processing Facility at Kennedy Space Center will accommodate the majority of the research facility and experiment launch site processing. In addition, the Space Experiment Research and Processing Laboratory (SERPL) is being built at Kennedy Space Center as a partnering effort with the State of Florida to accommodate pre- and post- launch biological and life science experiment processing. SERPL will replace the existing Hanger L specialized science processing facility at KSC, providing state-of-the-art animal care facilities, general experiment processing and integration labs, ground control capabilities, and flight experiment processing. Areas include Biotechnology, Microgravity, Space Agriculture, Biomedicine, Conservation Biology, and Microbial Ecology. The facility is envisioned to be a magnet facility in a potential Space Station Commerce Park at Kennedy Space Center. This potential project would also be a product of close teamwork between NASA and the State of Florida, and would represent an opportunity to enhance commercial and academic access to the spaceport and International Space Station.

2) *Conduct research during assembly in a diversified set of disciplines.*

The second major strategy is to conduct research beginning during the early assembly period. To maintain the viability of NASA's priority research programs, the ISS must support a range of disciplines during assembly. The research strategy must develop and take advantage of as many flight opportunities as possible.

The Research Program is poised to take advantage of available flight opportunities to the ISS. Resources are available to deliver rack level hardware on many of the utilization and assembly flights throughout the assembly process. Middeck locker level experiments and logistics resupply will be available on most utilization and assembly flights in the Shuttle middeck and Multi-Purpose Logistics Module (MPLM).

The Rev. F Assembly sequence added flights ULF1 and 13A.1. ULF1 offers the opportunity to deploy racks earlier than previously planned, and flight 13A.1 offers the opportunity to deliver additional middeck and sub-rack level research hardware. Flights 5A.1 through ULF1 enable NASA to deploy the first 10 research racks to orbit. These 10 racks represent the core of NASA's total planned rack level outfitting. The 10 racks include two Human Research Facilities (HRF), six EXPRESS racks, Microgravity Science Glovebox (MSG), and the Window Observational Facility (WORF).

Delivery of the Human Research Facilities (HRF) and EXPRESS racks aboard the ISS early in assembly will allow deployment of payloads supporting many disciplines. The HRF will facilitate early research in the life sciences discipline. The EXPRESS rack program will provide valuable flight opportunities for middeck locker scale experiments and product development in the areas of fundamental biology, biotechnology, biomedical sciences, fluid dynamics and combustion research.

The Microgravity Science Glovebox will allow small-scale research to be carried out in the various fields of materials science, fluid mechanics, combustion, biotechnology, cell science, and acceleration measurement. Research can be conducted delivered to this rack on a frequent basis, advancing a broad range of areas.

Even prior to the delivery of the Window Observational Research Facility (WORF), Earth observations will be conducted through the research-quality window in the US Laboratory. With the delivery of WORF, NASA will position the Earth science discipline to take advantage of the unique opportunities available on the ISS.

The revised Assembly Sequence also opened the opportunity to utilize the attached payload sites on the truss as early as possible. The Alpha Magnetic Spectrometer is currently scheduled for flight UF4, which moved up in the assembly sequence significantly.

As further refinement of resource availability and flight opportunities continue, the racks delivered early in the assembly sequence will be postured to take advantage of these resources. Delivery of future research facilities will continue to closely track the buildup of ISS accommodations to ensure the research programs ramp up as soon as capability becomes available. The research program will continue to be aligned with the availability of on-orbit resources, including crew time, power and upmass capabilities.

3) *Facilitate the commercial utilization of the space environment.*

The stage has been clearly set for commercialization of space. NASA continues to reserve 30% of the resources for commercial development of space. NASA and Congressional activities in 1999 facilitated the environment for accelerated commercial development of space, and commercial agreements have already been implemented for use of some of the reserved resources.

NASA has signed an agreement with Dreamtime Holdings, Inc., for multimedia services across NASA. Preparations are underway to fly a High Definition TV camera aboard the ISS. Volume on flight 7A.1 has been reserved for this camera and associated hardware. The camera qualification is underway. Within the bounds of the agreement, this flight will be the first of many for Dreamtime equipment aboard the Shuttle and ISS.

NASA also recently signed an agreement with SkyCorp, Inc. to deploy a developmental test of a satellite via a crewmember EVA. The satellite will be based on a G4 Macintosh server, and be an Internet server deployed in space. The concept behind this type of deployment may dramatically reduce costs of satellite deployment by reducing redundancy requirements, structure requirements for ELV launch, and by providing a checkout by a crewmember prior to deployment. Currently, schedules for SkyCorp's development cycle are under review.

NASA's commercial research programs for ISS will take advantage of the new opportunities for space flight operations provided by the ISS, and a distinctly new operating environment. Among other activities, the commercial research programs for the ISS will concentrate on commercial protein crystal growth, antibiotic production, and plant growth research. The commercial protein crystal growth activities for ISS are underway at the Center for Biophysical Sciences and Engineering, the plant growth research at the Wisconsin Center for Space Automation and Robotics, the Center for Bioserve Space Technologies, and their industrial affiliates.

NASA is also continuing to study options for creating a Non-Government Organization (NGO) to manage ISS utilization and commercial development. The National Research Council formed a "Task Group on Institutional Arrangements for Space Station Research" and delivered a report in December 1999, which generally supported the NGO concept. The Office of Space Flight also commissioned an "ISS Operations Architecture Study" which delivered a report in August 2000 also supporting the NGO concept to "improve management of user interface and enhance ISS productivity". A NASA internal study is ongoing to document the utilization functions, evolutionary options and total cost projections. A final report will be delivered to NASA management with decisions expected in FY 2001. Procurement activities may also be initiated in FY 2001.

<u>SCHEDULE & OUTPUTS</u> - The project schedules will be reviewed during the restructuring activity and adjusted as part of the program reassessment.

Research Projects

Centrifuge & Life Sciences Glovebox CDR Plan: Rotor 3rd Qtr FY 2001 LSG 4th Qtr FY 2001 Revised: TBD	The Life Sciences Glovebox (LSG) PDR was completed during early FY2000.
Fluids & Combustion Facility (FCF) FCF System PDR Plan: 4th Qtr FY 2000 Revised: 2nd Qtr FY 2001	The FCF System PDR was initiated in 1st Qtr. 2001 and will be concluded in 2nd Qtr. FY2001.
FCF Combustion Integrated Rack (CIR) CDR Plan: TBD	
Materials Science Research Facility Rack 1 CDR Plan: 4th Qtr FY 2000 Revised: TBD	The MSRF PDR was completed during FY2000.
Materials Science Research Facility Rack 2 CDR Plan: 4th Qtr FY 2000 Revised: 1st Qtr FY 2003 Revised: TBD	
Human Research Facility Rack 2 CDR Plan: 4th Qtr FY 2001	The HRF Rack 2 will complete a CDR in late FY2001 and begin Fabrication/Testing during FY2002.

Gravitational Biology Facility Rack 1 Fab/Assy/Test Plan: 4th Qtr FY 2000 Revised: TBD	
Biotechnology Facility PDR Plan: 3rd Qtr FY 2000 Revised: 3rd Qtr FY 2001 Revised: TBD	
Low Temperature Microgravity Physics Facility PDR Plan: 2nd Qtr FY 2000 Actual: 4th Qtr FY 2000	

Utilization Support

EXPRESS Racks 1 & 2 Final Testing and Reviews Plan: 2nd Qtr FY 2000 Actual: 1st Qtr FY 2001	The first two EXPRESS Racks are at KSC undergoing final testing and subrack integration in preparation for launch on 6A.
Complete POIC/USOC and facilities outfitting Plan: 1st Qtr FY 2000 Actual: 1st Qtr FY 2000	The Payload Operations Integration Center (POIC) and U.S. Operations Center (USOC) at MSFC completed hardware installation and checkout during early FY 2000.
EXPRESS Pallet PDR Plan: 4th Qtr FY 1999 Revised: 1st Qtr FY 2001	The EXPRESS Pallet PDR is planned to begin in early FY2001. Brazil continues to experience ongoing funding problems with the Pallet.
WORF Block 1 CDR Plan: 2nd Qtr FY2000 Actual: 2nd Qtr FY2000	The Window Observational Research Facility (WORF) completed its CDR in mid FY2000.

Communications Link Activation Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	The initial communication link activation from the Huntsville Operations Support Center (HOSC) to the Space Station Control Center (SSCC) to support payload training and operations occurred during late FY 1999. Full communication link activation occurred in FY 2000.
PPS Build 3 Plan: 1st Qtr FY 2000 Actual: 2nd Qtr FY 2000	The Payload Planning System (PPS) capabilities required to support Cadre-Payload Developer Training was completed during mid 2000. Build 3 was completed in FY2000.

ACCOMPLISHMENTS AND PLANS

Research Projects - FY 2000

On-orbit research on the ISS has begun, even with the limited resources available at this point in the assembly sequence.

The Commercial Generic Bioprocessing Apparatus (CGBA) was launched and returned on flight 2A.2B. This commercially developed payload housed experiments from Yale University and Tulane University. In part based on this successful flight, Tulane, NASA and Fisk Ventures, Inc. signed a partially exclusive license agreement to allow commercial use of NASA's bioreactor for ground-based research, potentially leading to further flight-based studies on the ISS.

The Protein Crystal Growth-Enhanced Gaseous Nitrogen Dewar (PCG-EGN) was the first long-duration experiment on ISS. It was launched aboard flight 2A.2B, and the experiment and its samples were returned to Earth on flight 3A. Proteins were crystallized in this Dewar for analysis in laboratories on the ground. Notable for this payload is the connection to middle and high schools in several states. The Principal Investigator has worked with numerous middle and high school science teachers and students to train them in aspects of protein crystallization, allowing students to prepare samples that ultimately were flown aboard this payload. The samples were returned to the high schools for analysis. The Dewar will be flown, with different protein samples on flights 5A and 5A.1.

The Middeck Active Control Experiment (MACE-II) is a payload sponsored through an interagency agreement by the Department of Defense. The payload tests critical elements of satellite control by actively damping vibrations of a large structure. This payload was launched aboard flight 2A.2B, and placed aboard the ISS for operation by the first ISS Expedition crew.

These first experiments all went from identification of flight opportunity, through the analytical integration process, to flight in eight months. While the sheer number of future experiments will preclude a compressed schedule for all payloads, this shortened integration process addresses a long-standing concern showing that NASA is capable of integrating and flying experiments on short notice.

Numerous additional experiments are being actively prepared for the first few ISS increments, including payloads in human life sciences, fundamental biology, structural biology, education, Earth observation, cell biology, fluid physics and materials processing as well as a number of commercial activities. Members of the first five Expeditions have undergone training or continue to be trained on payload activities.

Technical Interchange Meetings were held with Dreamtime and SkyCorp payload developers in preparation for launch. These are the first two commercial (reimbursable) payloads manifested for the ISS.

The first ISS research rack, the Human Research Facility (HRF), completed final integration and test at Kennedy Space Center. The HRF and sub-rack payloads are integrated into the Multi-Purpose Logistics Module (MPLM) in preparation for launch on 5A.1.

EXPRESS Racks 1 and 2 continued final testing and began integration into the MPLM in preparation for launch on 6A. EXPRESS Racks 4 and 5 are in final integration and testing in preparation for delivery to KSC in mid FY2001.

The Human Research Facility prototype rack and EXPRESS Rack 1, with all subrack payloads incorporated, were successfully installed into the U.S. Laboratory for the Integrated Compatibility Test. This test verified successful operation of multiple racks in a “day-in-the-life” type environment inside the U.S. Lab.

The Microgravity Science Glovebox is in final integration and test in preparation for delivery to KSC in mid 2001 for launch on UF2. A training unit was delivered to Johnson Space Center in late FY2000 to support crew training.

The Biotechnology and Fluid Physics subrack payloads completed their CDRs in mid FY 2000 in preparation for launch on 7A.1.

The Human Research Facility Rack 2 continued in detailed design in preparation for launch on ULF1.

The Program also continued development activities on the remaining facility-class and subrack level payloads.

Much of Gravitation Biology Facility hardware is under development. The Avian Development Facility and Biomass Production System continued fabrication and test in preparation for launch on 8A. The Habitat Holding Rack #1 is in fabrication in preparation for launch on UF3. The Insect Habitat completed a PDR mid FY 2000. The Incubator completed a CDR early FY 2001.

The Life Sciences Glovebox conducted a PDR in early FY 2000 and will initiate a delta PDR in early FY 2001. The Centrifuge Rotor initiated a PDR in late FY 2000 and will continue with a delta PDR into FY 2001. The Glovebox and Rotor will continue in detailed design in preparation for launch late in the assembly sequence.

The Microgravity Science Research Facility Rack 1 completed a PDR in mid-FY2000. NASA and ESA each completed preliminary designs of the first inserts in FY 2000.

The Fluids Integrated Rack and Combustion Integrated Rack of the Fluids and Combustion Facility continued with preliminary design, defining requirements and interfaces with both the ISS, as well as with its unique science modules. The Multi-User Droplet Combustion Apparatus (MDCA) hardware concepts and requirements definition continue in concert with the four investigations identified to conduct operations in the CIR. The Light Microscopy Module and its four investigations also continue to define concepts, requirements, and interfaces with FIR.

Early utilization payloads provided from GRC include the Physics of Colloids in Space (PCS), Space Acceleration Measurement System (SAMS II) and the Microgravity Acceleration Measurement System (MAMS). Each completed development, integration and testing with the EXPRESS Rack at KSC and are ready for launch and ISS on-orbit operations commencing with Flight 6A.

The Low Temperature Microgravity Physics Facility completed a CDR and continued working through formulation phase in FY 2000. LTMPF initiated discussion with NASDA to resolve issues pertaining to payloads using the Japanese Experiment Module-Exposed Facility.

The SAGE III attached payload completed an instrument CDR and continued in assembly and test in FY 2000. The Hexapod Pointing Platform, which will be provided under the ESA Early Utilization Agreement, will continue in detailed design.

The Alpha Magnetic Spectrometer attached payload completed a PDR in mid-FY2000 and continued in detailed design.

The WORF Rack completed a CDR in mid-FY2000. Hardware fabrication and integration has begun for the flight rack, as well as for a ground rack (for payload development and testing) and a trainer rack (for crew training and ground troubleshooting).

Research Projects - FY 2001

The MACE-II payload and three additional crew and education payloads were operated in the early weeks of the first Crew Increment. These additional payloads include the Crew Earth Observation camera, the Earth Knowledge Acquired by Middle School (EarthKAM) camera and the Education-Space Exposed Experiment Developed for Students (SEEDs) experiment.

The Program will maximize early research opportunities on the Human Research Facility (HRF) Rack 1 and EXPRESS Racks scheduled for delivery to the ISS in early FY2001.

The HRF was launched on 5A.1. Following on-orbit rack checkout and test, research operations will be initiated in the areas of radiation monitoring, medical research and care, bone and muscle studies, psychosocial studies, pulmonary function, and renal stone formation. Human Research Facility research equipment will include the Bonner Ball Neutron Detector (BBND), Active and Passive Dosimeters, Dosimetric mapping (DOSMAP), Phantom Torso Reflex Experimental Kit.

The first two EXPRESS Racks will be launched on flight 6A. EXPRESS Rack level ISS research operations will begin following on-orbit rack level checkout and test. Some of the early sub-rack level payloads will include the Physics of Colloids in Space, Advanced Astroculture, Commercial Generic Bioprocessing Apparatus, Protein Crystal Growth-Single Thermal Enclosure, Commercial Protein Crystal Growth-High Density, Space Acceleration Measurement System-II, Microgravity Acceleration Measurement System, Dynamically Controlled Protein Crystal Growth, Advance Protein Crystallization Facility, Zeolite Crystal Growth, Advanced Protein Crystallization Facility, Space Drums, Biotechnology Cell Science Stowage, Biotechnology Refrigerator, Biospecimen Temperature Controller, and Gas Supply Module.

EXPRESS Rack 2 will be the first Active Rack Isolation System (ARIS) rack. The ARIS was designed to isolate selected racks from ISS vibrations while holding the racks in place in their rack bays. An experiment in EXPRESS Rack 2 will characterize the performance of the ARIS system and provide valuable data for microgravity experiments on later flights.

Near-term work in 2001 will include flight processing of EXPRESS Racks 3, 4, and 5 and their sub-rack payloads, and the Microgravity Science Glovebox.

EXPRESS Racks 4 and 5 will be delivered to KSC in early FY 2001 in preparation for launch on 7A.1. EXPRESS Rack 3 is in final integration and testing in preparation for delivery to KSC in late FY2001 and launch on UF2.

Biotechnology and Fluid Physics subrack payloads will complete final testing and integration in preparation for on-orbit operations in the EXPRESS Racks. They will continue and extend investigations begun on Shuttle missions into the growth and development of mammalian tissue culture and the exploration into the physics and properties of colloids in microgravity.

The Microgravity Sciences Glovebox will be delivered to KSC in mid-FY2001 in preparation for launch on UF2. CSLM continues fabrication, assembly and test in FY2001 and will conduct a Pre-Ship Review (PSR) in the 4th Qtr. FY2001 and 1st Qtr. FY2001 in preparation for launches on ULF1, 11A and 12A.

The Alpha Magnetic Spectrometer attached payload will complete a CDR in mid FY2001. Fabrication will also begin in FY2001.

WORF Rack fabrication, integrated hardware and software testing, and crew training will continue throughout FY2001 with a delivery of the flight unit to the Kennedy Space Center in early FY2002. Sub-rack payload development for WORF continues.

The EXPRESS Pallet PDR is planned for early FY2001. NASA continues to work with Brazil towards resolution of funding issues for their planned EXPRESS pallet contributions.

Development activities on the remaining research facilities will be reviewed during the budget restructuring activity and the facilities will be built in a priority order as fiscal resources are available.

Research Projects – FY 2002

Research projects plans for FY 2002 will be defined as part of the program reassessment

The Human Research Facility and first four EXPRESS Racks will continue on-orbit operations. The Microgravity Sciences Glovebox will complete final integration and test in preparation for launch on UF2. Both racks will initiate research operations following on-orbit rack level checkout and test.

EXPRESS Rack 3, WORF and the Human Research Facility Rack 2 will complete final test and integration in preparation for launch on UF2 and ULF1. The three racks will initiate research operations following on-orbit rack level checkout and test.

Flights UF1, UF2, and ULF1, scheduled for FY 2002, will be the first utilization flights focused on maximizing research opportunities. These flights will continue to deliver research racks and provide middeck and MPLM upmass and volume to support research resupply requirements.

Biotechnology and Fluid Physics subrack payloads will continue on-orbit operations in the EXPRESS Racks. The subracks include the Single-Locker Thermal Enclosure (STES), Dynamically Controlled Protein Crystal Growth (DCPCG) and Enhanced Gaseous Nitrogen (EGN) for the Biotechnology field to carry out crystal growth experiment on medically important macromolecular materials, and Physics of Colloids in Space (PCS and PCS Plus) used to perform experiments for studying the processes of crystal formation.

The Alpha Magnetic Spectrometer attached payload will continue fabrication/assembly/test in FY2001 in preparation for launch.

Development activities on the remaining research facilities will be reviewed during the budget restructuring activity and the facilities will be built in a priority order as fiscal resources are available.

Utilization Support Infrastructure – FY 2000

This past year, many accomplishments were made in the preparation and conduct of crew training for US payloads. Training requirements for each payload manifested on the early increments were established through a series of Training Strategy Team meetings. Development and verification of lesson plans, courseware, training mockups and simulators, and crew procedures and displays were successfully accomplished. Training for the Increment 2 and 3 prime crews and backup crews were conducted at JSC training facilities and received excellent evaluations from the Astronaut Office. Increment 2 payload training is complete; Increment 3 payload crew training is 75% complete.

Many payload operations support capabilities were delivered and tested in preparation to support payload operations beginning in FY 2001. Training for the Expedition Crews for the first four Increments and ground support personnel training continued in preparation for research operations in FY 2001.

The first Payloads Logistics Conference was conducted to support logistics planning and implementation.

The POIC facility completed its hardware installation and checkout in FY 2000. The POIC is currently providing off-line planning support to current onboard payloads and the Increment 1 crew launched on Oct 31, 2000. In addition, initial operations interface work such as Joint Operation Interface Procedures (JOIP's) have been accomplished with Mission Control Center - Houston and Mission Control Center - Moscow. Operations interface coordination is in progress and will continue over the next year with Japan, ESA, Italy, and Canada. Planning, training and operations product development for Increments 2 and 3 has been in progress since FY 1999, Increments 4 and 5 began in FY 2000.

Requirements and course development for Ground Support Personnel (GSP) training was accomplished this pass year. Certification criteria for each position (both POIF cadre and Payload Developer) that will sit on console during an increment were established and baselined. Training processes, curriculums, and flows were also baselined. Course development by subject matter experts was completed and verified and training was begun.

Simulations to date have included POIC Cadre only simulations, Cadre to Telescience Support Center/Remote Payload Investigator simulations, and a voice protocol with the MCC-H. To help prepare the Utilization community for ISS operations, the POIC Cadre has conducted eight Payload Operations Integration Working Group (POIWG) face-to-face meetings between the POIC staff and the Payload Investigators (PI's) to discuss the POIC processes and procedures over the last two years.

Cadre and Payload Developer training for Increments 2, 3, and 4 are currently underway. Training for Payload Developers is done remotely, requiring no travel.

The HOSC Integrated Support Team (IST) supports the POIC facility. The IST provides building, workstation, network and software support for both simulation and real-time operations. IST staffing has completed approximately 80% of its training requirements and will complete 5A-required training in early FY 2001.

The PPS currently is comprised of five major subsystems and is 80% complete. PPS already offers the capabilities needed to support the limited payload operations planned during early ISS assembly, as well as functions required to support planning and integration of later payloads. One of the key features in use today is the capability to exchange planning data with the system operations planners at JSC, as well as the International Partner planners in Russia, Europe, Japan and Canada.

The TReK project successfully completed its Operations Readiness Review in mid FY 2000. Release 1.0 of this software was produced in-house at the MSFC. TReK systems are currently in use for Cadre-Payload Developer simulation training in preparation for Increment 2.

Data circuits for Telescience Support Centers (TSC) have been activated to Boeing Seattle, University of Wisconsin, University of Alabama-Birmingham, University of Colorado and Harvard University all in support of Increment 2 payload operations. Remote site video will be broadcast via satellite to the CONUS and received via 0.9-meter dish at each site and 2 meter dish at each TSC.

Delivery of Payload Rack Checkout Units to Kennedy Space Center and Glenn Research Center was accomplished in 2000, bringing to four the number of units currently operational at NASA Centers.

The final two STEP production units were delivered in early FY2000, bringing the total complement to 13 units, which are currently deployed around the U.S. and also in Europe.

A Preliminary Engineering Review for Science Experiment Research Laboratory (SERPL) was completed.

The Payload Software and Verification Facility was brought on-line this year and has been used to develop flight software products for the 5A.1 and 6A missions. In addition, software products were delivered for the Multi-Element Integrated Test and Integrated Compatibility tests with the U.S. Lab.

The EHS software development is packaged into a series of builds that bring on increasing amounts of capability as required to support an increasingly complex onboard payload complement. Build 4.1, representing a system total of 4.1 million software lines of code (SLOC), was completed and deployed in FY 2000 to support early facility testing. The POIC successfully transmitted payload commands to the ISS Systems Integration Laboratory and to KSC last year to confirm system functionality. The 4.2 build series will bring the SLOC total to 4.2 million and provides capability up to Increment 5. Build 4.2-7.3 comprises the functions necessary to support full POIC support for ISS Increment 2 through 5A.1.

The Payload Data Library currently contains data submissions from 88 payloads/investigations to support preflight integration of manifested payloads. Future PDL software development will include the incorporation of additional payload integration documentation into electronic format, data import/export capability, electronic configuration management and International Partner interfaces.

Utilization Support Infrastructure – FY 2001

Utilization support plans will be defined as part of the program reassessment

Payload operations support capabilities will continue to be delivered and tested in preparation to support on-orbit payload operations beginning in FY 2001. Training for the Expedition Crews and ground support personnel training will continue in preparation for research operations.

The first operation of the Telescience Support Centers (TSC) will occur in mid-FY2001 with launch of the Human Research Facility and EXPRESS Racks 1 and 2 containing several microgravity investigations. Telescience operations of these payloads will be conducted from the JSC and GRC TSCs, with remote operations via TReK to the Principal Investigations (e.g., PCS Investigator Professor Weitz at Harvard University).

The POIC will begin full operational support at flight 5A.1, the start of Increment 2. Planning, training and operations product development for Increments 6 and 7 will commence in FY2001. The POIC is continuing to provide off-line planning support to current onboard payloads and the Increment 1 crew launched on October 31, 2000.

Cadre and Payload Developer training will continue in FY2001 for later increments. In FY2001 we will also begin closer dialog with the International partners regarding the interface training necessary for the ground control centers to operate effectively together.

Crew training requirements, development and verification phase for a number of facility and subrack payloads will continue in FY2001. This will be an ongoing process as new payloads are identified and manifested. In addition training for the Increment 2 and 3 crews will be completed and training for subsequent crews will begin.

Payload Joint Integrated Simulations, which include MCC-H, MCC-M, SSTF/Crew and the POIC/TSC/Remote Payload Investigators, will commence in early FY 2001 and continue up until Increment 2 launch. In addition, subsequent Increment training will commence and overlap previous Increments' training. The POIC Cadre team for early Increments is comprised of 14 controllers. Five teams will rotate (not all shifts fully staffed) to provide 24 x 7 support for on-orbit operations beginning on 5A.1.

Cadre team size will expand to 19 at Assembly Complete to support the full onboard payload complement of 37 International Standard Payload Racks.

The HOSC Integrated Support Team will complete flight 5A required training in early FY2001.

The POIC video distribution satellite transponder service will come online in early FY2001. To reduce network costs, the program is developing voice over the Internet software to enable eight multiplexed voice channels to be streamed via the Internet to as many as 500 Remote Payload Investigators (RPI) eliminating the need for a separate voice instrument and dedicated circuit to each RPI site. This software is planned for completion in early FY2001 with an Operations Readiness Review scheduled in mid FY2001.

The current baseline Ku-Band communication data rate for the ISS ground facilities is 50 Mbps. The onboard Ku-Band system is capable of transmitting at 150 Mbps. The CSOC contractor (Lockheed) has been funded to provide a Subsystem Functional Design Review (SSFDR) of an enhancement of the ground segment to the 150 Mbps rate. The SSFDR is schedule for completion in early FY2001. At that point the ISSP will decide whether to proceed with implementation or shelf the design. A current communication usage study shows that the onboard payload complement will exceed the baseline bandwidth capability at UF-5 (2005).

The EHS Software build 4.2-7.3 is currently scheduled for build ready in early FY 2001, followed by POIC Operations Readiness Review. Build 4.2-10 will support flight 7A.1 and be operational in FY2001. Build 5.0 provides remote commanding capability to geographically separated scientists and two-year telemetry storage. It is required to support flight 9A (Increment 7) is scheduled to be delivered to the POIC for testing in FY2001. Build 5.0 represents a facility total of 4.5 million SLOC and approximately 97% of the total planned software development of the POIC core functions.

TReK Release 2.0 is planned for deployment in FY2001. This release will enable remote usage of enhancements in EHS Build 5.0.

In FY2001 and beyond, capability will be added to Payload Test and Checkout System and Payload Rack Checkout Units (PTCS/PRCU) to test external payloads.

The Payload Planning System final delivery of operational code is planned for early FY2001. PPS already offers the capabilities needed to support the limited payload operations planned during early ISS assembly, as well as functions required to support planning and integration of later payloads.

Utilization Support Infrastructure – FY 2002

Payload operations facilities will continue to support on-orbit payload operations. Payload crew training will continue to support later increments.

On-orbit operation of five payload racks (HRF-1, EXPRESS 1, 2, 4, and 5) will continue in FY2002.

EXPRESS rack 3 will complete processing at KSC and will launch on UF-2 in FY2002.

Future upgrades and expansions of the utilization support capabilities will be reviewed during the budget restructuring activity and prioritized and completed as fiscal resources are available.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION RUSSIAN PROGRAM ASSURANCE

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
Russian Program Assurance...	200,000	24,040	
[Construction of Facilities included]	[1,000]	[--]	

* FY 2002 funding is currently under review and allocations to RPA will be determined as part of program assessments.

PROGRAM GOALS

NASA's approach to contingency planning is to incrementally fund only those activities that permit the United States to continue to move forward should the planned contributions of our ISS partners not be delivered as scheduled, rather than to assume the responsibilities of other ISS partners. It is a process based on: 1) identification of risks; 2) development of contingency plans to reduce these risks; 3) establishment of decision milestones and the criteria by which action will be taken; and, 4) implementation of contingencies as necessary. The RPA funding provides contingency activities to address ISS program requirements resulting from potential delays or shortfalls on the part of Russia in meeting its commitments to the ISS program, allowing the U.S to move forward with ISS assembly or operations in spite of potential shortfalls. These contingency activities are not intended to protect against the complete loss of Russian contributions. That impact would cause an extended delay to the program, necessitating additional crew return, life support, reboost, and guidance and control capabilities to replace planned Russian contributions, and result in a significantly more costly and less robust space station.

BACKGROUND

For several years Russia experienced significant economic challenges resulting in the Russian Aviation and Space Agency (Rosaviakosmos) receiving only a fraction of its approved budget. These shortfalls resulted in schedule slips of the ISS hardware and operations support that Russia was responsible for funding and providing. To accommodate this shortfall, the U.S. developed a three step contingency plan and initiated specific developments to protect the ISS schedule and capabilities in the event of further Russian delays or shortfalls. In spring 1997, NASA embarked on the initial steps of a contingency plan to provide U.S. capabilities to mitigate the impact of further Russian delays. Step one consisted primarily of the development of an Interim Control Module (ICM), built by the U.S. Naval Research Laboratory for NASA, to provide command, attitude control, and reboost functions to provide a backup capability in the event the Russian Service Module was significantly delayed or not successfully provided. Over the next year further delays continued on the Russian elements. During summer 1998, NASA initiated activities to implement additional contingency plans to provide flexibility for the United States in the event of further Russian delays or shortfalls. These consisted primarily of development of a U.S. Propulsion Module, enhancing logistics capabilities, modifying the Shuttle fleet for enhanced Shuttle reboost of ISS, and procurement of needed Russian goods and services to support Russian schedules for the Service Module and early ISS Progress and Soyuz launches.

STRATEGY

With the successful deployment of the Russian Service Module, and Russia's recent positive performance overall, NASA has reassessed its contingency plans, and determined that much of the Russian assurance efforts were no longer a priority relative to other program needs. Based on the increasing costs to planned RPA elements and the baseline program, and the reduced impact of future Russian non-performance, NASA placed the ICM in "call-up" mode in FY 2000. The ICM is stored at the Naval Research Lab awaiting final disposition. In FY 2001, the Propulsion Module Project was ended, and most RPA funds were transferred to the Vehicle program. Remaining FY 2001 funds are reserved for changes, including the potential procurement of safety-related Russian goods and services. Decisions to implement the remainder of the RPA Program, or to request that remaining funds be reprogrammed to support baseline program needs, are pending the outcome of the baseline program reassessment expected to be completed in the Spring and Summer of FY 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE STATION CREW RETURN VEHICLE

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
X-38/Crew Return Vehicle	75,000	89,802	

* FY 2001-2002 funding is currently under review and allocations to X-38/Crew Return Vehicle (CRV) will be determined as part of the program assessments. CRV production (Phase 2) was funded in the SAT account in the FY 2001 budget runout. Those funds were redirected to Space Station in the HSF account to address cost growth on the program.

PROGRAM GOALS

The safety of the crew for the International Space Station is of critical importance. The Russian Soyuz vehicle provides a capability to return the crew from orbit if needed for life threatening emergencies that may arise on orbit. Continued sole reliance on a single Soyuz capability limits the crew size for the ISS and poses operational and programmatic impacts. Each Soyuz can only transport a crew of three and has to be changed out after about six months on orbit. A more capable crew return vehicle that overcomes the limitations of the Soyuz is the most desirable long term approach for ensuring crew safety. A goal of the Crew Return Vehicle (CRV) project is to leverage the technologies, processes, test results, and designs developed in the preliminary technology development work carried out in the X-38 project and related contractor studies of a CRV.

The Crew Return Vehicle (CRV) project will initiate work towards an independent U.S. crew return capability for the ISS. The CRV would accommodate safe return for up to seven crew under the following scenarios:

- Crew member(s) ill or injured while the space shuttle orbiter is not at the station
- Catastrophic failure of the station that makes it unable to support life and the space shuttle orbiter is not at the station or is unable to reach the station in the required time
- Problem with the space shuttle that makes it unavailable to re-supply the station or change-out crew in a required timeframe

STRATEGY FOR ACHIEVING GOALS

NASA has funded the X-38 project to reduce the risk of developing a CRV. The X-38 design has a strong foundation from the lifting body research and technology developments carried out since the 1960's. The plan to transition from X-38 research and development to CRV design and development is comprised of the following phases:

- Phase 0 - An unfunded observation period in which contractors interact with the X-38 project team. This effort began 20 July 1998 and is now complete. Five companies participated in this phase which was performed with X-38 Advanced Projects funding.
- Phase 1a – Selected contractor(s) will perform delta design tasks to convert the X-38 design into an operational CRV design and participate in the X-38 flight test program as a part of CRV verification and validation. Phase 1a is fixed cost, runs for about 12 months and includes tasks and deliverables up through Preliminary Design Review and Interim Design Review.
- Phase 1b – After Phase 1a, one contractor will continue the CRV design development and test program support up through the X-38 vehicle 201 space flight test and CRV Critical Design Review. This phase will also be fixed cost and will last about 20 months.
- Phase 2a – This phase of CRV production is a cost-plus-incentive-fee contract for delivery of the first two operational CRVs. It is expected to last for about 24 months.
- Phase 2b – This phase is a fixed-cost contract for delivery of the third and fourth operational CRVs and is slated to run about 27 months.

These phases will include three primary tasks:

- Perform delta design tasks necessary to convert the X-38 design into an operational CRV design, and perform necessary system integration internally and with STS and ISS.
- Support atmospheric and space flight tests of X-38 prototype vehicles as part of CRV validation.
- Perform production of the CRV operational vehicles.

In the FY 2001 budget runout, CRV Phase 2 funds for development and production were included in the SAT appropriation, to better integrate CRV activities with broader space transportation architecture activities and goals in the Space Launch initiative. As a result of cost growth on the ISS program, these funds were allocated back to the Space Station HSF budget to address this growth. No funding for Phase 2 activities are identified in this budget. NASA will continue to pursue atmospheric testing of the X-38 and is assessing the affordability of completing the space flight test relative to other program priorities. Future decisions to develop and deploy additional U.S. elements or enhancements beyond U.S. core complete, like the CRV, will depend on the quality of cost estimates, resolution of technical issues, and the availability of funding through efficiencies in Space Station or other Human Space Flight programs and institutional activities.

The recent program reassessment indicating significant ISS cost growth has led to the redirection of Phase 2 funding previously planned in the SAT appropriation, to mitigate ISS funding requirements. Further review may also adjust Phase 1 plans.

SCHEDULE & OUTPUTS (X-38 PATH) - The project schedules will be reviewed during the restructuring activity and adjusted as part of the program reassessment.

Start Contractor Observation period Plan: July 1998 Revised: Completed	Beginning of period in which potential contractors observe X-38 Program flight demonstration test and development activity.

CRV Request For Proposal release for Phase 1a Plan: March 1999 Actual: November 1999	Release RFP for a funded period in which two contractors will perform delta design tasks to convert the X-38 design in an operational CRV design and participate in flight-testing.
Phase 1a Start Plan: October 1999 Revised: 4th Qtr FY 2000 Revised: June 2001	Contractor(s) will perform delta design tasks to convert the X-38 design in an operational CRV design and participate in flight-testing. Matures CRV through PDR and IDR.
Phase 1b Start (new to plan) Plan: June 2002 Revised: Under review	Single contractor matures CRV through CDR. Supports X-38 space flight test, data analysis and design impacts to CRV in support of CRV verification and validation.
Phase 2 CRV development contract Plan: December 2000 Revised: June 2002 Revised: TBD	Award of development contract for operational CRVs. To be split into a cost- plus contract for CRVs 1&2 and fixed-cost contract for CRVs 3&4 (currently no funding is identified for Phase 2)

ACCOMPLISHMENTS AND PLANS

FY 2000

In FY 2000, the project completed the fifth successful X-38 atmospheric free flight test in which the flight control system was validated. According to the requirements of the independent assessment team, a full scale 7500 square foot parafoil was manufactured and successfully flown twice in platform drop tests. X-38 vehicle 131 was modified to match the operational body shape and delivered to JSC for outfitting in preparation for an early FY 2001 flight. The RFP for Phase 1(a) was issued to industry, proposals were received and reviewed, and the source evaluation board process was largely completed. An additional 40 maturity gate actions were completed in FY 2000, bringing the total to 97 complete out of 110, securing the approval of NASA's Program Management Council to proceed on to the award of preliminary CRV design contract Phase 1(a). The coupled loads analysis on the Deorbit Propulsion Stage was also completed.

FY 2001

X-38 and CRV plans will be defined as part of the program reassessment.

The X-38 project continued with atmospheric vehicle and parafoil flight testing, and the space flight vehicle build as the prototype for the ISS Crew Return Vehicle (CRV). X-38 flight testing has successfully demonstrated numerous technologies needed for the operational CRV. Among the more important of these is flight of the operational body shape and full operational scale parafoil, advanced flight control software, electro-mechanical actuators and laser activated pyrotechnics. The first of two 80% scale atmospheric test vehicles, vehicle 131R, was modified to match the expected CRV production vehicle body shape and successfully completed its first free flight test in November of 2000. Free flight tests progressively match larger portions of the CRV operational reentry flight profiles to enhance performance validation as X-38 testing plays an important role in the overall CRV flight certification plan. Two more atmospheric flights are planned for this year.

In addition to the flight test progress, several important X-38/CRV reviews were successfully completed. The Shuttle Payload Safety Review, the X-38 Entry Safety Review, the KSC Ground Safety Review, an Aerodynamics Peer Review and a Landing Site review were all completed with several minor issues cited but no significant issues identified.

Structural design changes to the X-38 Deorbit Propulsion Stage (DPS) were completed and all propulsion components were mounted to the main deck. The flight unit DPS is on schedule for delivery to NASA in spring 2001 in preparation for the vehicle 201 space reentry flight test tentatively scheduled for early 2003. The vehicle 201 build and verification matured to 70-80% completion.

FY 2002

X-38 and CRV plans will be defined as part of the program reassessment.

In addition to continuing the X-38 prototyping work mentioned above, the following provides an indication of the design and development work which would be conducted, using both civil servants and contractors.

CRV Vehicle Subsystems

NASA Tasks
Avionics work would include continued development of the CRV inertial guidance system (SIGI – System of Interactive Guidance and Information); avionics instrumentation; radiation-hardened computer system network elements; operating and flight system software; and communication system signal processors. Flight dynamics work would include simulation-based development and verification of the CRV flight controls. Mechanisms work would include delivery of electro-mechanical actuators (EMAs) and laser pyros, and EMA testing. Parafoil work would continue with testing, new parafoil procurements, and integrated structural dynamic modeling. Thermal Protection System component procurement would also continue.

Phase 1a and 1b Contractor Tasks
Contractor tasks would be focussed on designs of CRV subsystems including avionics computers, networks and data busses; instrumentation and sensors; electrical power system; communications system; engineering support; laser altimeter; data recorder; avionics testbed; human computer interface; flight software; and interconnect wiring and connectors. Mechanisms work will be performed on the berthing/docking design and fin mechanisms. Manufacturing work will continue on the berthing/docking module engineering development unit; metallic structural parts materials and machining; composite structural parts materials and manufacturing; and tooling. Structures work would begin on structural, hatch, window and couch design.

Systems Engineering and Operations

Safety, Reliability, and Quality Assurance, and Systems Engineering and Integration work would be performed as NASA primary tasks supported by the Phase 1a contractor(s).

Operations tasks include analyses of CRV separation (from Space Station) dynamics, continuing development of landing site and site selection requirements, and development of crew displays and controls requirements. Mission operations tasks include Mission Control Center and facility design requirements, modeling, and development of flight and ground procedures and flight rules. Logistics and maintenance tasks would focus on development of a spares program. Kennedy Space Center tasks include development of launch support and logistics flight operations requirements.

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE SHUTTLE**

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Safety and Performance Upgrades	468,800	--	--	HSF 2-6
Shuttle Operations	2,530,900	--	--	HSF 2-19
Flight Hardware	--	1,970,555	2,067,200	HSF 2-25
Ground Operations	--	581,518	604,100	HSF 2-32
Flight Operations	--	272,998	271,000	HSF 2-36
Program Integration	--	293,752	341,500	HSF 2-39
(Safety Allocation - non-add)	--	(255,836)	(405,500)	
Total	2,999,700	3,118,823	3,283,800	
Distribution of Program Amount by Installation				
Johnson Space Center	1,666,200	1,863,723	2,072,800	
Kennedy Space Center	176,400	161,500	184,100	
Marshall Space Flight Center	1,000,000	1,021,200	954,300	
Stennis Space Center	38,400	38,700	47,000	
Dryden Flight Research Center	4,800	4,800	4,800	
Ames Research Center	6,600	1,700	--	
Langley Research Center	200	--	--	
Goddard Space Flight Center	--	8,900	2,900	
Headquarters	107,100	18,400	17,900	
Total	2,999,700	3,118,823	3,283,800	

GENERAL

The Space Shuttle program provides launch services to a diverse set of customers, supporting launch, on-orbit operations, and return to earth, of payloads that range from small hand-held experiments to large laboratories. While most missions are devoted to NASA-sponsored payloads, others including industry, partnerships, corporations, academia, national and international agencies exercise wide participation. NASA, and the U.S. and international scientific communities are beneficiaries of this approach. The Space Shuttle is a domestically and internationally sought-after research facility because of its unique ability to provide on-orbit crew operations, rendezvous/retrieval and payload provisions, including power, telemetry, pointing and active cooling.

The Space Shuttle continues to prove itself to be the most versatile launch vehicle ever built. This has been demonstrated by: (1) rendezvous missions with the Russian Space Station Mir; (2) advancing life sciences and technology through long-duration Spacelab and Spacehab missions; and (3) repairing and servicing the Hubble Space Telescope, enabling many new discoveries in Space Science. The Space Shuttle has also performed rescue and retrieval of spacecraft and has begun the assembly of the International Space Station (ISS). The Space Shuttle services numerous cooperative and reimbursable payloads involving foreign governments and international agencies. The focus of international cooperation, for which the Space Shuttle is uniquely suited, is the assembly and operational support of the International Space Station, already underway with the first seven ISS assembly missions successfully completed (STS-88, STS-96, STS-101, STS-106, STS-92, STS-97, and STS-98).

The Space Shuttle program participates in the domestic commercial development of space, providing limited flight opportunities to NASA's Centers for Commercial Development of Space. These non-profit consortia of industry, academia and government were created to conduct commercially applied research activities by encouraging industry involvement leading to new products and services through access to the space environment. Cooperative activities with the National Institutes of Health (NIH), the National Science Foundation (NSF), the Department of Defense (DoD) and other U.S. agencies are advancing knowledge of health, medicine, science and technology. Prime examples include many cooperative NASA-NIH experiments and the Shuttle Radar Topography Mission, a joint DoD/NASA payload, flown in FY 2000.

Consolidation of contracts to a single prime contract is progressing successfully since the award of the Space Flight Operations Contract (SFOC) on October 1, 1996. Phase II of the transition is underway, with the first production hardware contract (Solid Rocket Booster) transferred into SFOC in FY 1998. The remaining schedule for further transition is under review. NASA will continue to pursue Space Shuttle privatization opportunities that improve the Shuttle’s safety and operational efficiency. This will include continued implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor.

Continued safe operation of the Space Shuttle is a high priority, in particular to ensure the Space Shuttle’s ability to support assembly and operations of the International Space Station. Investments in Shuttle safety improvements have been made over the last several years while, at the same time, the Shuttle budget was reduced by about a third through efficiencies and contract consolidation. Having achieved these reductions, continued improvements in Shuttle safety is a priority. Therefore, this request continues to significantly improve safety and protect the nation’s investment in the Station and Shuttle. A $405.5 million Safety Allocation is requested in the FY 2002 Space Shuttle budget to address Shuttle safety improvements through hardware/software upgrades, personnel, facility, or other investments. This is a significant increase over $255.8 million in FY 2001 for the Shuttle safety allocation that was in the previous request.

NASA has been conducting an external review to assess how the Safety Allocation funds can most effectively be used to improve the safety of the Space Shuttle, to include investments in hardware/software upgrades, personnel, facilities, or other safety-related areas. NASA will proceed with investment activities once Authority To Proceed (ATP) has been accomplished. The highest priority safety upgrades currently include: the Cockpit Avionics Upgrade (CAU), the Electric Auxiliary Power Unit (EAPU), and Advanced Health Monitoring System (AHMS) for the Space Shuttle main engines (SSME). The Cockpit Avionics Upgrade, , which is still under study, is for improved avionics in the Shuttle cockpit. This will improve the situational awareness of the crew, and better equip them to handle potential flight anomalies. Additional investments will be assessed as part of the external review, and candidates include further upgrades to the SSME, advanced thrust vector control for the solid rocket boosters, and investments in shuttle infrastructure.

Space Shuttle safety investments are an important element of NASA's strategy for an Integrated Space Transportation Plan (ISTP). These investments in Shuttle safety are an important element of the ISTP, and ensure continued safe Shuttle operations through this decade, and provide assurance that the Shuttle could operate into the next decade, if needed.

The Space Shuttle operations prime contractor, United Space Alliance, was awarded the Space Flight Operations Contract (SFOC) on October 1, 1996 based upon a phased approach to consolidate operations into a single prime contract for operational activities. The first phase began in late 1996 with 12 operational and facility contracts being consolidated from the majority of the effort previously conducted by Lockheed Martin and Boeing North American (the two corporations which comprise the USA joint venture). The second phase will add other operations work to the contract after the contractor has had an appropriate amount of time to evolve into its more responsible role in phase I. NASA will continue to pursue Space Shuttle privatization opportunities that improve the Shuttle's safety and operational efficiency. This will include continued implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor. Transition could take another 1-2 years and employ approximately 7300 equivalent persons at steady state. The specific schedule for all transitions is currently under review. The reasons for this phased approach are two-fold:

1. The ongoing major development projects will be completed.
2. The transition to the prime can occur at a more measured pace.

The roles and missions of the contractor and government relationships have been defined to ensure program priorities are maintained and goals are achieved. The SFOC contractor is responsible for flight, ground and mission operations of the Space Shuttle. The accountability of its actions and those of its subcontractors are evaluated and incentivized through the use of a combined award/incentive fee structure of the performance-based contract. NASA, as owner of assets, customer of operations services and director of launch/flight operations, is responsible for (a) surveillance and audit to ensure compliance with SFOC requirements and (b) internal NASA functions. Further, NASA retains chairmanship of control boards and forums responsible for acceptance/rejection/waiver of Government requirements while the SFOC contractor is responsible for requirement implementation. The SFOC contractor is required to document and maintain processes/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight.

PROGRAM GOALS

The primary goals of the Shuttle Operations program in priority order are: (1) fly safely; (2) meet the flight manifest; (3) improve supportability and (4) improve the system.

NASA policy planning assumes the Space Shuttle will need to be capable of supporting the critical transportation requirements for at least this decade including the assembly of the International Space Station and International Space Station operations. In order to maintain a viable human transportation capability that will operate into this new century and support NASA's launch requirements, specific program investments are required. These investments are consistent with NASA's strategy of ensuring the Space Shuttle remains viable until a new transportation system is operational.

STRATEGY FOR ACHIEVING GOALS

All decisions regarding program requirements, programmatic changes and budget reductions are guided by the program's goals as stated above. Three key elements of this budget request are: (1) the continued transition to a single prime contractor for space flight operations; (2) continuation of safety and supportability upgrades; and (3) Orbital Maintenance Down Periods (OMDPs) to be conducted at Palmdale, California.

The overall strategy for the Shuttle Operations budget is to request funding levels sufficient to allow the Space Flight Operations Contract to meet the intended flight rates. This includes appropriate contingency planning in both budget and schedule allowances to assure transportation and assembly support to the International Space Station program. At the same time it also incentivizes the contractor to identify opportunities for reductions in operations costs while still ensuring the safe and reliable operation of the Space Shuttle. The continued transition of activities to the Space Flight Operations Contract represents a key element of this strategy.

This budget is based on an average of six flights annually with a surge capability to seven flights and is a change from previous years. In FY 2000 only four shuttle missions were flown. In FY 2001 and FY 2002 seven flights are planned. In FY 2001 all seven flights are dedicated International Space Station (ISS) assembly and utilization missions. FY 2002 includes five ISS flights, a Hubble Space Telescope servicing mission, and a dedicated microgravity research mission. The flight rate is anticipated to continue at 6 per year through FY 2006 as supported by this budget. This manifest supports the Nation's science and technology objectives through scheduled science missions and continued assembly and operations of the ISS.

In addition to flying safely, restructuring the program and conducting a single prime consolidation, we are completing activities that have been in the Safety and Performance Upgrades program, and have transitioned to the new budget structure which integrates safety and supportability upgrades into the four major budget elements. The Shuttle Operations program's strategy for the Safety and Performance Upgrades budget has been to fund those modifications and improvements which will provide for the safe, continuous and affordable operations of the Space Shuttle system for the foreseeable future. This is an essential element of the launch strategy required for continuing supportability to the ISS. Completion of selected projects, termed “Phase I” upgrades, has improved Space Shuttle safety and payload-to-orbit performance by 13,000 pounds. The additional payload-to-orbit performance allows the Shuttle to achieve the orbital inclination and altitude of the International Space Station.

This budget also includes Supportability upgrades to develop systems, which will combat obsolescence of vehicle and ground systems in order to maintain the program’s viability into this new century. Vendor loss, aging components, high failure rates of older components, high repair costs of Shuttle-specific devices and negative environmental impacts of some outdated technologies are areas to be addressed.

This budget provides funds required for modifying and improving the capability of the Space Shuttle to ensure its viability as a safe, effective transportation system and scientific platform. It also addresses increasingly stringent environmental requirements, obsolescence of subsystems in the flight vehicle and on the ground and capital investments needed to achieve reductions in operational costs. Work continues on the Alternate Fuel Turbopump for the planned introduction of the Block II Space Shuttle Main Engine (SSME) in FY 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

SAFETY AND PERFORMANCE UPGRADES

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Orbiter improvements	[183,700]		
	--		
Other orbiter improvements..	117,500		
Upgrades	66,200		
Propulsion upgrades	181,600		
Space shuttle main engine upgrades..............................	144,500		
[Alternate Turbopump program]..................................	[41,300]		
[Large Throat Main Combustion Chamber]..................	[1,400]		
[Phase II+ Powerhead Retrofit]....................................	[2,900]		
[Other main engine upgrades]....................................	[98,900]		
Solid rocket booster improvements	1,100		
Super Lightweight tank	500		
Upgrades	35,500		
Flight operations & launch site equipment upgrades..........	92,500		
Flight operation upgrades...	14,200		
Launch site equipment upgrades...................................	30,000		
Upgrades	48,300		
[Checkout and Launch Control System] [included above]	[42,200]		
Construction of Facilities	11,000		
Total..	468,800		

GENERAL

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning and also the effect these projects have on the overall operation of the Space Shuttle System. Success depends on developing these projects and getting them implemented to help ensure the Space Shuttle's safe operation and improving the reliability of the supporting elements.

Beginning in FY 2001, there is a restructured budget format for the Space Shuttle Program. The old nomenclature, "Safety and Performance Upgrades" (S&PU), will no longer be used as a budgetary naming convention. The new structure provides much more clarity with the Upgrades activity and the Safety Allocation included in this request. The S&PU as a budget category included many other items in addition to Upgrades, which led to confusion as to what were and were not considered upgrades. Under the new structure, upgrades are clearly delineated under each of the four line items of Flight Hardware, Ground Operations, Program Integration and Flight Operations.

The following is a brief description of these activities.

Orbiter Improvements

The Orbiter improvements program provides for enhancements of the Space Shuttle systems, produces space components that are less susceptible to damage and maintains core skills and capabilities required to modify and maintain the Orbiter as a safe and effective transportation and science platform. These activities are provided by Boeing Reusable Space Systems (as a major subcontractor to United Space Alliance (USA)) in two major locations: the Huntington Beach, California facility provides engineering support; and the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support as discussed below, as well as manufacturing and testing. Other activities that support this effort are subsystem management engineering and analysis conducted by Lockheed-Martin Corporation and development and modifications required for support to the extravehicular capability conducted by Hamilton Sundstrand.

An Orbiter Maintenance Down Period (OMDP)/Orbiter Major Modification (OMM) occurs when an Orbiter is taken out of service periodically for detailed structural inspections and thorough testing of its systems before returning to operational status. This period also provides opportunities for major modifications and upgrades, especially those upgrades that are necessary for improving performance to meet the International Space Station operational profile.

Propulsion Upgrades

The main engine safety and performance upgrade program is managed by the Marshall Space Flight Center (MSFC) and supports the Orbiter fleet with flight-qualified main engine components and the necessary engineering and manufacturing capability to address any failure or anomaly quickly. The Rocketdyne Division of Boeing Reusable Space Systems is responsible for operating three locations that provide engine manufacturing, major overhaul, component recycle and test. They are:

(1) Canoga Park, California which manufactures and performs major overhaul to the main engines;
(2) Stennis Space Center (SSC), Mississippi for conducting engine development, acceptance and certification tests; and
(3) Kennedy Space Center (KSC), Florida where the engine inspection checkout activities are accomplished at the KSC engine shop.

Engine ground test and flight data evaluation, hardware anomaly reviews and anomaly resolution are managed by the Marshall Space Flight Center (MSFC). The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West Palm Beach, FL.

Flight Operations and Launch Site Equipment Upgrades

The major flight operations facilities at Johnson Space Center (JSC) include the Mission Control Center (MCC), the flight and ground support training facilities, the flight design systems and the training aircraft fleet that includes the Space Shuttle Training aircraft and the T-38 aircraft.

The major launch site operational facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC) and three Mobile Launcher Platforms (MLPs). The most significant upgrade in this account is the Checkout and Launch Control System (CLCS) at KSC.

Construction of Facilities

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, reclaim, replace and restore facilities at Office of Space Flight Centers to improve performance, address environmental concerns of the older facilities and to ensure their readiness to support the Space Shuttle Operations.

PROGRAM GOALS

NASA policy planning assumes the Space Shuttle will need to be capable of supporting the critical transportation requirements for at least this decade including the assembly of the International Space Station and International Space Station operations. In order to maintain a viable human transportation capability that will operate into this new century and support NASA's launch requirements, specific program investments are required. These investments are consistent with NASA's strategy of ensuring the Space Shuttle remains viable until a new transportation system is operational.

STRATEGY FOR ACHIEVING GOALS

This budget provides funds required to modify and improve the capability of the Space Shuttle to ensure its viability as a safe, effective transportation system and scientific platform. It also addresses increasingly stringent environmental requirements, obsolescence of subsystems in the flight vehicle and on the ground and capital investments needed to achieve reductions in operational costs. Work continues on the Alternate Fuel Turbopump for the planned introduction of the Block II Space Shuttle Main Engine (SSME) in FY 2001.

SCHEDULES AND OUTPUTS

The Safety and Performance Upgrade program is measured by the success it has in accomplishing the ongoing projects consistent with approved schedule and cost planning. Success depends on developing/implementing these projects to help ensure the Space Shuttle's safe operation, improving the performance and reliability of the supporting elements and improving efficiencies to reduce operational costs. This budget addresses all elements of the Space Shuttle program and is managed through an approval process that ensures that new projects are evaluated, approved and initiated on a priority basis and that existing projects meet established cost and schedule goals. Significant milestones are listed below:

Orbiter Improvements

Multifunction Electronic-Display System (MEDS) - MEDS is a state-of-the-art integrated display system that replaced the current Orbiter cockpit displays with an integrated liquid crystal display system.

MEDS Initial Operational Capability (IOC) Plan: 2nd Qtr FY 1999 Revised: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	First flight of a MEDS equipped Orbiter. (OV-104/STS-101), Launched on May 19th, 2000.

Global Positioning System (GPS) - GPS will replace the current TACAN navigational system in the Orbiter navigation system when the military TACAN ground stations will be phased out. The GPS certification for the Space Shuttle Operation will be completed in second quarter of FY 2002.

Orbiter Install Complete Plan: 4th Qtr FY 1998 Revised: 2nd Qtr FY 1999 Actual: 2nd Qtr FY 1999	Installation and checkout of hardware on OV-104 at Palmdale.
Complete GPS operational Capability Plan: Under Assessment	Initial operation of GPS without TACAN system. (Under Assessment.)

<u>Orbiter Maintenance Down Periods / Orbiter Major Modifications (OMDP/OMM)</u>

Initiate Discovery (OV-103) OMDP	Conduct routine maintenance and structural inspection. Also, install the MEDS upgrade, hardware for GPS capability.
Plan: 3rd Qtr FY 2000	
Revised: 1st Qtr FY 2002	Revised due to flight and scheduling delays

Propulsion Upgrades

<u>Space Shuttle Main Engine Safety Improvements</u> - Introduction of the Block I and Block II changes into the Space Shuttle's Main Engine (SSME) program will improve the SSME margin of safety by a factor of two. The interim Block IIA configuration (Block II without the ATP High-Pressure Fuel Turbo Pump (HPFTP)) implements the safety and performance margins provided by the Large Throat Main Combustion Chamber (LTMCC) while the HPFTP development problems are solved.

High Pressure Fuel Turbopump Design Certification Review	Certifies Block II engine with alternate high pressure fuel turbopump for flight
Plan: 2nd Qtr FY2001	Delta DCR planned for March 2001

First flight of Block II engine	The high-pressure fuel turbopump will be combined with the LTMCC and previous Block I upgrades.
Plan: 4th Qtr FY 1997	
Revised: 1st Qtr FY 1998	
Revised: 4th Qtr FY 2000	Revised due to testing delays
Revised: 3rd Qtr FY 2001	Revised due to technical issues, planned first flight in June 2001

<u>Flight Operations and Launch Site Equipment Upgrades</u>- Upgrades continued in FY 2000 and FY 2001 to the Launch Site Equipment at KSC, which will increase reliability and reduce obsolescence.

CLCS "Atlas" Delivery Plan: 2nd Qtr FY 1999 Actual: 1st Qtr FY 2000	The Atlas delivery represents the first fully operational delivery for the project. This delivery will allow the start of usage of a CLCS set of hardware, system software and application software for processing of Space Shuttle components in the Hypergolic Maintenance facility at KSC.
SAIL set installation Plan: 2nd Qtr FY 1999 Actual: 4th Qtr FY 2000	The CLCS Shuttle Avionics Integration Lab (SAIL) set completed facility modifications and hardware installation and activation. This set will be used to validate CLCS application software against real flight-like hardware.

Space Shuttle Safety Upgrades - New upgrades are being initiated by the Space Shuttle program to help ensure continued safe operations of the Space Shuttle by improving the margin of safety. The dates are planning estimates rather than commitments, as the program is still in an early definitional phase, but all new Space Shuttle safety upgrades are planned to be fully integrated into the Shuttle fleet by FY 2007. The Space Shuttle program is in the process of developing detailed project plans.

Cockpit Avionics Upgrades (CAU) - This new safety upgrade improves crew situational awareness and reduces flight crew workload. It provides automated control of complex procedures and increases the level of flight crew autonomy. Functional capabilities include enhanced Caution & Warning (a system to monitor critical instrumentation parameters), abort situation monitoring and trajectory assessment, improved integrated vehicle instrumentation displays, Remote Manipulator System (RMS) safety enhancements for the robotic arm, and rendezvous and proximity operations.

Cockpit Avionics Upgrades
(CAU) Start
Plan: 1st Qtr FY 2000
Actual: 1st Qtr FY 2000

Electric Auxiliary Power Unit (EAPU) – Orbiter - Battery powered electric motors will replace turbines powered by hydrazine, a highly flammable and environmentally hazardous fluid. The turbines are used to drive the hydraulic pumps providing control for the orbiter such as engine movement, steering, and braking functions. The upgrade eliminates hydrazine leakage/fire hazards, eliminates turbine overspeed hazards, and reduces toxic materials processing hazards. The requirement definition and system trade studies of the EAPU have been developed.

EAPU Authority to Proceed for implementation Phase Plan: 4th Qtr FY 2001	Pending the approval of "Authority To Proceed" from NASA-Headquarters Program Management Council

Space Shuttle Main Engine (SSME) Advanced Health Management System (AHMS) - Another new safety upgrade, this project entails a suite of instrumentation, software, and computational capabilities for real-time engine assessment, rapid turnaround, and reduction in invasive, manual processing and testing. The system includes vibration monitoring, engine performance monitoring, and overall health analysis. It consists of two phases; Phase 1 reduces pump failures, Phase 2 monitors engine health and makes real time changes to increase probability of successful missions.

SSME AHMS Phase 1 Start
Plan: 1st Qtr FY 2000
Actual: 1st Qtr FY 2000

SSME AHMS Phase 1

Preliminary Design Review Plan: 3rd Qtr FY 2000 Actual: 3rd Qtr FY 2000	
SSME AHMS Phase 1 Critical Design Review Plan: 4th Qtr FY 2000 Revised: 3rd Qtr FY 2001	Completion of Critical Design Review will allow drawings to be released for production to proceed. Delay due to requirements changes for lightning protection and replacement of memory retention batteries with non-volatile batteries

External Tank (ET) Friction Stir Weld (FSW) – Provides superior welds with a highly repeatable process for the ET. 20% in crease in weld strength and 95% reduction in weld repairs.

External Tank Friction Stir Weld Authority to Proceed Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	
External Tank Friction Stir Weld Preliminary Design Review Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	

Construction of Facilities

Complete Phase II Restore Firex Pumps and Piping at LC-39 Plan: 2nd Qtr FY 2000 Revised: 2nd Qtr FY 2001	Restoration is needed. Pumps are currently inadequate to provide spray coverage during an emergency. This project removes and replaces existing Firex pumps, motors, refurbishes diesels, and installs a new underground pipe between the pump station and Pads A and B. Delayed due to pad availability.
Start Pad B Surface and Slope Restoration at LC-39 Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	This project provides for initial repair of the Pad B surface concrete, pad slopes, and the crawlerway grid path. Follow on project is under assessment.

Complete Repair of Pad A Flame Deflector & Trench at LC-39 Plan: 4th Qtr FY 2000 Actual: 3rd Qtr FY 2001	This project provides for repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall. Delay due to additional repairs required along with availability of pad for implementation
Complete Cell E Restoration Plan: 3rd Qtr FY 2000 Actual: 3rd Qtr FY 2000	This project restores and modifies the common solution return systems and lining for the cell. The cell lining is breaking down and requires restoration work at Michoud Assembly Facility.
Complete Towway Support Bldg. (Phase II) Plan: 4th Qtr FY 2000 Actual: 1st Qt. FY 2001	This project is the SSP portion of the Support Facility at the Towway of the SLF.
Start Repair VAB Elevator Controls Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	This Project replaces the elevator systems in the Vehicle Assembly Building. The controls, cabs and cableway systems are obsolete and parts are no longer available. A recent fire in one of the VAB elevator controls caused a concern with the safety of the systems. This was identified as a safety project.
Start Phase I Rehabilitation of A Test Stand at SSC for SSME Testing Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	The rehabilitation of the A-2 Test Stand used for SSME testing must be accomplished in six (6) phases. The first two are reported here. (The six phases includes one phase for A-1 Repair) The rehabilitation includes civil/structural/Architectural repairs, replacement and mods for Test Stand structural members, Flame defector, roof and walls, flume repair, diffuser, rollup doors, tunnel repair. Mechanical repairs, replacement and mods to cryogenic piping, run tank insulation, gas supply mods, chiller diffuser, Firex repairs including Flame deflector IW pipe, monorail overhaul, HPI water valves. Electrical repairs, replacement, mods to the MCC's, electrical panels, switchgear, bus, power supply, disconnect switches and fire alarm. The Space Shuttle Program plans to offload testing from A-2 to A-1 for some tests to allow down time on the A-2 Test Stand for extensive Rehabilitation on the A-2 Stand.
Start Phase II Rehabilitation of A Test Stand at SSC for SSME Testing Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	Phase II includes asbestos abatement, rehabilitation of run tank insulation, rehabilitation of shop air system, and replacement of 480 volt switch gear

ACCOMPLISHMENTS AND PLANS

A significant portion of the Safety and Performance Upgrades (S&PU) budget has been dedicated to preventing the deleterious and costly effects of obsolescence, especially at a time when the program is undertaking the challenge of reducing the costs of operations. This portion of the budget contains projects that impact every element of the Space Shuttle vehicle. The S&PU budget supports replacing Tactical Airborne Navigation System (TACAN) with Global Positioning System (GPS), improving the onboard Shuttle communication system, upgrading the T-38 aircraft with maintainable systems, replacing elements of the launch site complex, upgrading major elements of the training facilities at Johnson Space Center, testing of main engine components at Stennis Space Center, testing of Orbiter reaction control systems at the White Sands Test Facility and replacing critical subsystems in the Kennedy Space Center facility complex.

The Space Shuttle program rationale for supportability upgrades is founded on the premise that safety, reliability and mission supportability improvements must be made in the Shuttle system to continue to provide safe and affordable operations through at least this decade. These will enable safe and efficient Shuttle operations during the International Space Station era while providing a robust testbed for advanced technologies and a variety of customers.

The Space Shuttle Upgrade activity is planned and implemented from a system-wide perspective. Individual upgrades are integrated and prioritized across all flight and ground systems, ensuring that the upgrade is compatible with the entire program and other improvements. Selection of new upgrades through the review process approved by the Associate Administrator for Space Flight, the Program Management Council (PMC) and the Administrator is utilized. Space Shuttle upgrades are developed and implemented in a phased manner supporting one or more of the following program goals:

- Fly safely
- Meet the manifest
- Improve supportability
- Improve the system

Safety

Micrometeoroid Protection upgrades was completed for OV-105 in FY 2000 and for OV-102 in FY 2001. OV-103 is planned to be completed in FY 2002. (discussed more thoroughly in Orbiter Improvements, below). These improvements included:

- isolation valves for the radiator cooling loops to increase orbiter survivability
- “armoring” the radiator panels
- putting additional thermal protection on the wing leading edges to make them more damage tolerant

The radiator modifications reduced the risk of early end of mission caused by a leak from 1 in 60 flights to 1 in 300-500, depending on attitude of the orbiter. The wing leading edge modifications reduced risk of orbiter loss upon reentry from 1 in 200 to 1 in 500-600, depending again on attitude of the orbiter.

Orbiter Improvements

The Space Shuttle Program performs hundreds of modifications throughout the year related to design changes to improve reliability, supportability, or meet new program requirements. These changes are a result of hardware failures or design enhancements identified through ground checkouts or in-flight. Additional orbiter modifications are approved as the International Space Station development advances and risk mitigation options are identified and implemented. The modifications are implemented either during a standard orbiter processing flow at Kennedy Space Center in Florida or during Orbiter Maintenance Down Period at Palmdale, California.

OV-102 completed its major modification and structural inspection at NASA's Palmdale facilities on February 23, 2001. The major modifications performed this period were the installation of the multifunctional electronics display system, electrical and structural provisioning for a global positioning system, Ultra High Frequency space communication system installation, thermal protection system improvements, radiator impact protection and fluid system isolation, Orbital Maneuvering System/Reaction Control System crossfeed line hardware replacement, Orbiter docking system electrical and structural provisioning, and installation of electrical wiring protection throughout the vehicle. Additionally, this Orbiter has been subjected to extensive wiring and structural corrosion inspections with repairs accomplished as needed.

To increase the space shuttle weight to orbit performance in support of International Space Station flights, the Space Shuttle program implemented a variety of orbiter weight reduction modifications. The project, completed in FY 2000 consisted of converting a variety of orbiter hardware from aluminum to composite or fabric structure. The components that were redesigned included the Lithium hydroxide rack assembly, the middeck pallets, middeck lockers and their associated trays, the middeck accommodations rack, and the tool stowage assembly. The approximate total orbiter weight reduction is 600 to 700 pounds pending the number of pallets flown.

Propulsion Upgrades

The most complex components of the Space Shuttle Main Engine (SSME) are the high-pressure turbopumps. Engine system requirements result in pump discharge pressure levels from 6,000 to 8,000 psi and turbine inlet temperatures of 2,000 Degrees F. In reviewing the most critical items on the SSME that could result in a catastrophic failure, 14 of the top 25 are associated with the turbopumps. The current pumps dependence on extensive inspection to ensure safety of flight have made them difficult to produce and costly to maintain. The Alternate Turbopump Program (ATP) contract with Pratt & Whitney was signed in December 1986 and called for parallel development of both the High Pressure Oxidizer Turbopump (HPOTP) and the High Pressure Fuel Turbopump (HPFTP) to correct shortcomings of the existing high pressure turbopumps. This objective is achieved by: utilizing design, analytical and manufacturing technology not available during development of the original components; application of lessons learned from the original SSME development program; elimination of failure modes from the design; implementation of a build-to-print fabrication and assembly process; full inspection capability by design and demonstrated design reliability through increased fleet leader testing. The turbopumps utilize precision castings, reducing the total number of welds in the pumps from 769 to 7. Turbine blades, bearings and rotor stiffness are all improved through the use of new materials and manufacturing techniques. The SSME alternate turbopump upgrades expand existing safety margins and reduce operational costs.

The SSME Powerhead is the structural backbone of the engine. The Phase II+ Powerhead has reduced the number of welds, improving producibility and reliability.

The heat exchanger uses the hot turbine discharge gases to convert liquid oxygen in a thin walled coil to gaseous oxygen for pressurization of the external oxygen tank. The current heat exchanger coil has seven welds exposed to the hot gas environment. A small leak in one of these welds would result in catastrophic failure. The new Single Coil Heat Exchanger eliminated all seven critical welds and tripled the wall thickness.

The Large Throat Main Combustion Chamber (LTMCC) first flight was on STS-89 (January 1998) and resulted in lower pressures and temperatures throughout the engine system thereby increasing the overall Space Shuttle system flight safety and reliability. The wider throat area accommodates additional cooling channels. Consequently, hot gas wall temperatures are significantly reduced increasing chamber life. The LTMCC design also incorporated new fabrication techniques to reduce the number of critical welds and improve the producibility of the chamber.

The development and production of the powerhead, heat exchanger and LTMCC are all being performed under contract with the Rocketdyne division of Boeing Reusable Space Systems.

The "block" change concept for incorporating changes into the main engine was introduced and baselined during FY 1994. The Phase II+ Powerhead, the Single Coil Heat Exchanger and the new high-pressure oxidizer turbopump comprise Block I. This change was introduced and flown for the first time in July 1995. The Block IIA configuration fielding the LTMCC was successfully flown in January 1998 on STS-89. In FY 2000 the Shuttle program successfully completed the Design Certification Review (DCR). In early FY 2001, a delta DCR was held and the pump green runs were completed at the Stennis Space Center. The Block II is scheduled to be flown in FY 2001 and incorporates the alternate high-pressure fuel turbopump with the Block IIA design. The end result of these engine improvements is an increase in the overall engine durability, reliability and safety margin and producibility. This is consistent with NASA's goals of decreasing failure probability and reducing Space Shuttle costs.

Increased safety margins and launch reliability on the Space Shuttle will also be realized through the implementation of new sensors (temperature, pressure and flow) for use in the SSME. SSME history has shown that the engine is more reliable than the instrumentation system; however, a transducer failure could result in a flight scrub or on-pad abort, failure to detect an engine fault, or an in-flight abort. These sensor upgrades have been completed and have been essential to improving the reliability of the Space Shuttle's launch capability.

Flight Operations and Launch Site Equipment Upgrades

These upgrades support pre-launch and post-launch processing of the four Orbiter fleet. Key enhancements funded in launch site equipment include: replacement hydraulic pumping units that provide power to Orbiter flight systems during ground processing; replacement of 16-year old ground cooling units that support all Orbiter power-on testing; replacement of communications and tracking Ku-band radar test set for the labs in the Orbiter Processing Facility and High Bays that supports rendezvous capability and the missions; communications and instrumentation equipment modernization projects that cover the digital operational intercom system, major portions of KSC’s 17-year old radio system and the operational television system; improvement of the

Space Shuttle operations data network that supports interconnectivity between Shuttle facilities and other KSC and off-site networks; replacement storage tanks and vessels for the propellants, pressurants and gases; an improved hazardous gas detection system; and fiber optic cabling and equipment upgrades.

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50% and will provide the building blocks to support future vehicle control system requirements. The Juno and Redstone phases of the CLCS were delivered in FY 1997. In these phases, the initial integration platform was defined, the engineering platform was installed and the interface with the math models was established. The Thor delivery was completed in FY 1998. During this phase, initial ground data bus interfaces were established and the system software was ported to the production platforms. The Atlas delivery in FY 1999 provided support for the initial applications for the Orbiter Processing Facility, the final applications for the Hypergolic Maintenance Facility (HMF), the math model validation, an interface to the Shuttle Avionics Integration Lab (SAIL) and hardware testing for SAIL.

In FY 2000, the HMF CLCS set was released for operational use for testing the Forward Reaction Control System (FRCS). Additionally, in FY 2000, a CLCS hardware set was installed into the SAIL, which allows for integrated testing utilizing SAIL's full-fidelity Shuttle system model. The CLCS hardware was installed into the CLCS Control Room 1 early in FY 2001, and the Titan system software release is scheduled for later in the year; together, these hardware and software activations will allow for full application software development and validation of those applications for OPF operations. Additionally, the HMF will be fully operational for both forward and aft propulsion system operations late in 2001. *In FY 2002, The Scout system software will be released, which provides the capability to execute OPF applications used for operations from the CLCS Control Room. The Scout release also allows completion of development for applications software to support VAB and Pad operations. VAB/Pad applications software can begin validation after the Scout release.* Continuing development activities are included in the Ground Operations section.

The Hardware Interface Modules (HIM), which are electrical command distribution systems that support the launch processing system (LPS) at KSC are over 25 years old and have experienced an increased failure rate and higher cost of repair over the past several years. The HIM upgrade (HIM II) replaces all chassis and cards with state-of-the-art "off the shelf" hardware to improve system reliability and maintainability. The production of the HIM II is complete, and installation into all launch support facilities should be completed in FY 2001.

The goal of the Operational Television System (OTV) Modernization project is to design and implement a state-of-the-art serial digital video surveillance facility that will meet the needs of the Space Shuttle Program today and through out the expected life of the program. Modernization of the Operational Television System (OTV) is based upon a phased engineering design and implementation strategy, which will enhance and automate the visual surveillance capability at KSC. A key element of the plan includes the integration of video camera operations and positioning, routing switcher, video monitoring and digital recorder control system into one unified control system (UCS) environment. The implementation of the OTV modernization project will operate concurrently with the current analog system and allow for an orderly phased transition to a completely digital video system. Other key elements of the OTV modernization project include, the upgrade from analog to digital video recorders (FY 1998), the purchase and installation of a new serial digital video routing switcher (FY 2000) and the orderly phased replacement of current analog video cameras. Due to the large number of cameras in the OTV system, the purchase and installation of new serial digital CCD cameras will be phased over a 3 to 4 year period starting FY 2001. When completed, in FY 2005, the OTV Modernization project will improve the OTV system reliability while providing the KSC Launch Team a new level of visual surveillance flexibility that promises to greatly enhance the value of the OTV system to the Shuttle program.

Construction of Facilities (CofF)

FY 2000 SSP CofF funding provided for improvements for facilities at KSC, MAF and SSC. At KSC there are 3 projects which complete the Towway convoy support restoration, repair Pad B Surface and Slope areas and repair the VAB elevators. The SSC project begins the rehabilitation of the A-2 Test Stand for Shuttle Testing and completes the MAF 480V Electrical distribution Rehab. Continued work on the Towway Support facility, Pad A Flame deflector and trench and the Cell E common Solution Return and Lining. Started work on the Convoy facility. Construction complete for Pad A FSS Elevator Restoration, MAF-480V, electrical distribution System Phase 3 and began construction on Phase 4. Continued construction in VAB HB 2 and 4 and crawlerway extension for Safe haven, began construction on the VAB Elevator Controls, first phase on the A-2 Test Stand restoration, Pad B surface and slope.

BASIS OF FY 2002 FUNDING REQUIREMENT

SHUTTLE OPERATIONS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Orbiter and integration	746,900	--	--
Propulsion	1,037,600	--	--
[External tank]	[359,200]	--	--
[Space shuttle main engine]	[195,700]	--	--
[Reusable solid rocket motor]	[347,900]	--	--
[Solid rocket booster]	[134,800]	--	--
Mission and launch operations	746,400	--	--
Total	2,530,900	--	--

GENERAL

Space Shuttle operations requirements are met through a combination of funds received from Congressional appropriations and reimbursements received from customers whose payloads are manifested on the Space Shuttle. The reimbursements are applied consistent with the receipt of funds and mission lead times and is subject to revision as changes to the manifest occur. The FY 1999 reimbursements totaled $35.9 million. The FY 2000 reimbursements were $22 million. The majority of FY 1999 and FY 2000 reimbursements are due to the Shuttle Radar Topography Mission. These standard service reimbursements offset the total budget for the Space Shuttle and have been assumed in the NASA direct funding requirements identified.

The Space Shuttle operations budget includes sustaining engineering, hardware and software production, logistics, flight and ground operations and flight crew operations for all elements while continuing to pursue environmentally necessary operations and manufacturing improvements. The single, prime contract is the Space Flight Operations Contract (SFOC) held by United Space Alliance comprising one-half of the Operations budget. As development items are completed, additional effort will be transitioned into SFOC. NASA will continue to pursue Space Shuttle privatization opportunities that improve the Shuttle's safety and operational efficiency. This will include continued implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor

P.L. 106-74 includes a limitation stipulating that $40 million of the amount provided for Human Space Flight "shall be available to the space shuttle program only for preparations necessary to carry out a life and micro-gravity science mission, to be flown between STS-107 and December 2001." As a result of a sustained flight rate of six per year, the date for this mission is currently under review.

Beginning in FY 2001, the Space Shuttle program has operated in a restructured budget format. There are several reasons why this new structure is beneficial. First and foremost, as the Program has become more operational in nature and undergone consolidation of its contracts into a single operational contract approach; the budget should reflect the way in which the Program is managed. The Space Shuttle Program is an operational effort, therefore, a budget structure consistent with the nature and maturity of the Program is being implemented. Also, the four major budget elements of Flight Hardware, Ground Operations, Program Integration and Flight Operations are consistent with the Space Flight Operations Contract (SFOC) Work Breakdown Structure. This consistency improves NASA's ability to account for and reconcile the work accomplished and expenditures.

Orbiter and Integration

The Orbiter project element consists of the following items and activities:

(1) Orbiter logistics: spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs) along with the workforce required to support the program; procurement of liquid propellants and gases for launch and base support;
(2) Production of External Tank (ET) disconnect hardware;
(3) Flight crew equipment processing as well as flight crew equipment spares and maintenance, including hardware to support Space Shuttle extravehicular activity;
(4) The sustaining engineering associated with flight software and the Orbiter vehicles;
(5) Various Orbiter support hardware items such as Pyrotechnic-Initiated Controllers (PICs), NASA Standard Initiators (NSI's) and overhauls and repairs associated with the Remote Manipulator System (RMS); and

The major contractors for these Orbiter activities are United Space Alliance for operations; and Hamilton Sundstrand for extravehicular mobility unit (EMU) operations.

Other support requirements are also provided for in this budget, including tasks that support flight software development and verification. The software activities include development, formulation and verification of the guidance, targeting and navigation systems software in the Orbiter.

System integration includes those elements managed by the Space Shuttle Program Office at the Johnson Space Center (JSC) and conducted primarily by United Space Alliance, including payload integration into the Space Shuttle and systems integration of the flight hardware elements through all phases of flight. Payload integration provides for the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable and safe cargo for each Space Shuttle mission. Systems integration includes the necessary mechanical, aerodynamic and avionics engineering tasks to ensure that the launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance and descend to a safe landing. In addition, funding is provided for multi-program support at JSC.

Propulsion

Lockheed Martin Corporation produces external Tanks in the Government-Owned/Contractor-Operated (GOCO) facility near New Orleans, LA. This activity involves the following:

(1) Procurement of materials and components from vendors;
(2) Engineering and manufacturing personnel and necessary environmental manufacturing improvements;
(3) Support personnel and other costs to operate the GOCO facility; and
(4) Sustaining engineering for flight support and anomaly resolution.

The program began delivering Super Lightweight Tanks to KSC in support of the performance enhancement goal required by the International Space Station in FY 1998. Only recurring costs associated with the Super Lightweight Tank are included in this account. Non-recurring costs are accounted for in the Safety and Performance Upgrades budget. Transition of the External Tank contract into Phase II SFOC is currently under review.

The Space Shuttle Main Engine (SSME) operations budget provides for overhaul and repair of main engine components, procurement of main engine spare parts and main engine flight support and anomaly resolution. In addition, this budget includes funding to the Department of Defense for Defense Contract Management Command (DCMC) support in the quality assurance and inspection of Space Shuttle hardware and funds for transportation and logistics costs in support of SSME flight operations. Rocketdyne, a division of Boeing Reusable Space Systems, provides the bulk of the engine components for flight as well as sustaining engineering, integration and processing of the SSME's for flight.

The Solid Rocket Booster (SRB) project supports:

(1) Procurement of hardware and materials needed to support the flight schedule;
(2) Work at various locations throughout the country for the repair of flown components;
(3) Workforce at the prime contractor facility for integration of both used and new components into a forward and an aft assembly; and
(4) Sustaining engineering for flight support.

USA is the prime contractor on the SRB and conducts SRB retrieval, refurbishment and processing at KSC.

The Reusable Solid Rocket Motor (RSRM) project has Thiokol of Brigham City, Utah as the prime contractor for this effort. This activity involves the following:

(1) Purchase of solid rocket propellant and other materials to manufacture motors and nozzle elements;
(2) Workforce to repair and refurbish flown rocket case segments, assemble individual case segments into casting segments and other production operations including shipment to the launch site;
(3) Engineering personnel required for flight support and anomaly resolution; and
(4) New hardware to support the flight schedule required as a result of attrition.

Mission and Launch Operations

Launch and Landing Operations provides the workforce and materials to process and prepare the Space Shuttle flight hardware elements for launch as they flow through the processing facilities at the Kennedy Space Center (KSC). The primary contractor is United Space Alliance. This category also funds standard processing and preparation of payloads as they are integrated into the Orbiter. It also provides for support to landing operations at KSC (primary), Dryden Flight Research Center (back-up) and contingency sites.

Operation of the launch and landing facilities and equipment at KSC involves refurbishing the Orbiter, stacking and mating of the flight hardware elements into a launch vehicle configuration, verifying the launch configuration and operating the launch processing system prior to lift-off. Launch operations also provides for booster retrieval operations, configuration control, logistics, transportation, inventory management and other launch support services. This element also provides funds for:

(1) Maintaining and repairing the Shuttle Data Center, which supports Space Shuttle processing as an on-line element of the Checkout and Launch Control System;
(2) Space Shuttle-related data management functions such as work control and test procedures;
(3) Purchase of equipment, supplies and services; and
(4) Operations support functions including propellant processing, life support systems maintenance, railroad maintenance, pressure vessel certification, Space Shuttle landing facility upkeep, range support and equipment modifications.

Mission and Crew Operations include a wide variety of pre-flight planning, crew training, operations control activities, flight crew operations support, aircraft maintenance and operations and life sciences operations support. The primary contractor is USA. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include:

(1) Flight planning;
(2) Preparing systems and software handbooks;
(3) Defining flight rules;
(4) Creating detailed crew activity plans and procedures;
(5) Updating network system requirements for each flight;
(6) Contributing to planning for the selection and operation of Space Shuttle payloads; and
(7) Preparation and plans for International Space Station assembly.

Also included are the Mission Control Center (MCC), Integrated Training Facility (ITF), Integrated Planning System (IPS) and the Software Production Facility (SPF). Except for the SPF (Space Shuttle only), these facilities integrate the mission operations requirements for both the Space Shuttle and International Space Station. Flight planning encompasses flight design, flight analysis and software activities. Both conceptual and operational flight profiles are designed for each flight and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data are stored in erasable memories located in the Orbiter, ITF Space Shuttle mission simulators and

MCC computer systems. Mission operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, ITF, IPS and SPF. Finally, Mission and Crew Operations include maintenance and operations of aircraft needed for flight training and crew proficiency requirements.

PROGRAM GOALS

The goal of Space Shuttle Operations is to provide safe, reliable and effective access to space. The FY 2000 budget was based on an average of seven flights annually with a surge capability to eight flights. In FY 2000 only four shuttle missions were flown. In FY 2001 and FY 2002 seven flights are planned. In FY 2001, all seven flights are dedicated International Space Station (ISS) assembly and utilization missions. FY2002 includes five ISS flights, the third Hubble Space Telescope servicing mission and a dedicated microgravity research mission. The flight rate is anticipated to continue at 6 per year through FY 2006 as supported by this budget. This manifest supports the Nation's science and technology objectives through scheduled science missions and continued assembly and operations of the ISS.

STRATEGY FOR ACHIEVING GOALS

Since FY 1992, cost reduction efforts have been successful in identifying and implementing program efficiencies and specific content reductions, while improving safety. Space Shuttle project offices and contractors have been challenged to meet reduced budget targets.

United Space Alliance was awarded the Space Flight Operations Contract (SFOC) on October 1, 1996. It includes a phased approach to consolidating operations into a single prime contract for operational activities. The first phase began in late 1996 with 12 operational and facility contracts being consolidated from the majority of the effort previously conducted by Lockheed Martin and Boeing North American (the two corporations which comprise the USA joint venture). The second phase will add other operations work to the contract after the contractor has had an appropriate amount of time to evolve into its more responsible role in phase I. NASA will continue to pursue Space Shuttle privatization opportunities that improve the Shuttle’s safety and operational efficiency. This will include continued implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor. Transition could take another 1-2 years and employ approximately 7300 equivalent persons at steady state. The specific schedule for all transitions is currently under review. The reasons for this phased approach are two-fold:

1. The ongoing major development projects will be completed.
2. The transition to the prime can occur at a more measured pace.

The roles and missions of the contractor and government relationships have been defined to ensure program priorities are maintained and goals are achieved. The SFOC contractor is responsible for flight, ground and mission operations of the Space Shuttle. The accountability of its actions and those of its subcontractors will be evaluated and incentivized through the use of a combined award/incentive fee structure of the performance-based contract. NASA as owner of assets, customer of operations services and director of launch/flight operations, is responsible for (a) surveillance and audit to ensure compliance with SFOC requirements and (b) internal NASA functions. Further, NASA retains chairmanship of control boards and forums responsible for acceptance/rejection/waiver of Government requirements while the SFOC contractor is responsible for requirement implementation. The SFOC contractor is required to document and maintain processes/controls necessary to ensure compliance with contract requirements and to sign a certification of flight readiness (CoFR) to that effect for each flight.

SCHEDULES AND OUTPUTS

Since the Space Shuttle program has both an operational and development component, performance measures related to the Space Shuttle program reflect a number of different activities ranging from missions planned and time on-orbit in Shuttle Operations, to development milestones planned for the Safety and Performance Upgrades program. The following sets of diverse metrics can be utilized to assess overall program performance.

	FY 2000		FY 2001		FY 2002
Operations Metrics	Plan	Actual	Plan	Revised	Plan
Number of Space Shuttle Flights	6	4			
Number of Days On-orbit	61	41			
Number of Primary Payloads Flown	6	2			

See the table on page 2-37 for comparison to FY 2001 and FY 2002.

Space Shuttle Missions and Primary Payloads

FY 2000		Plan	Actual/Revised
STS-103/Discovery	Hubble Space Telescope (HST) Servicing Mission 3A	--	December 1999
STS-99/Endeavor	Shuttle Radar Topography Mission (SRTM)	January 2000	February 2000
STS-101/Atlantis	Space Station #3 (Spacehab Cargo Module (ISS-03-2A.2a)	March 2000	May 2000
STS-106/Atlantis	Space Station #4 (Spacehab Cargo Module (ISS-04-2A.2b)	--	September 2000
STS-92/Discovery	Space Station #5 (ITS-Z1) (ISS-05-3A)	June 2000	October 2000
STS-97/Endeavor	Space Station #6 (PV Module) (ISS-06-4A)	July 2000	December 2000
STS-98/Endeavor	Space Station #7 (US Lab (ISS-07-5A)	August 2000	February 2001

ACCOMPLISHMENTS AND PLANS

In FY 2000, the Space Shuttle flew four times, including the Hubble Space Telescope Servicing Mission 3A that replaced failing gyros on the HST. The Shuttle Radar Topography Mission (SRTM), a joint DoD/NASA payload to study the earth, successfully mapped over 98 percent of the available terrain. Two flights to the International Space Station delivered equipment and supplies to set the stage for future assembly missions and to enable the first Expedition crew to live aboard.

BASIS OF FY 2002 FUNDING REQUIREMENT

FLIGHT HARDWARE

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
External Tank Production..		320,922	287,900
Space Shuttle Main Engine Production..............................		242,265	228,200
Space Shuttle Main Engine Test Support...........................		32,430	32,700
Reusable Solid Rocket Motor..		377,967	378,700
Solid Rocket Booster.....		137,197	128,400
Vehicle and EVA........		668,726	689,200
Flight Hardware Upgrades*		190,979	322,100
Total..		1,970,555	2,067,200

* The distribution of the Safety Allocation for FY 2001 and FY 2002 is under review, pending resolution of safety investment priorities including the independent review. Funds are shown under Flight Hardware Upgrades in the Flight Hardware budget line item, but will be shifted as appropriate, when investment priorities are finalized. This could include safety investments in personnel, facilities and infrastructure, or other safety-related areas.

PROGRAM GOALS

The goal of Flight Hardware programs is to produce and maintain the various components of the Space Shuttle vehicles and provide for the upgrades required for safe, reliable and effective access to space.

STRATEGY FOR ACHIEVING GOALS

The Flight Hardware program contain many of the elements previously budgeted in the Space Shuttle Operations budget under Orbiter and Integration and Propulsion Operations, along with work previously budgeted in Safety and Performance Upgrades in Orbiter Improvements and Propulsion Upgrades.

The Flight Hardware program provides for enhancements of the Space Shuttle and produces space components that are not susceptible to damage and maintains core skills and capabilities required for modifying and maintaining the Orbiter as a safe and effective transportation and science platform. These activities are provided by Boeing Reusable Space Systems (as a major subcontractor to United Space Alliance (USA)) in two major locations: the Huntington Beach, California facility provides engineering support; the Palmdale, California operation provides Orbiter Maintenance Down Period (OMDP) support as discussed below, as well as manufacturing and testing. Other activities that support this effort are subsystem management engineering and analysis conducted by Lockheed-Martin Corporation and development and modifications required for support to the extravehicular capability conducted by Hamilton Sundstrand.

The Flight Hardware program performs hundreds of modifications throughout the year related to design changes to improve reliability, supportability, or meet new program requirements. These changes are a result of hardware failures or design enhancements identified through ground checkouts or in-flight. Additional Orbiter modifications are approved as the International Space Station development advances and risk mitigation options are identified and implemented. The modifications are implemented either during a standard Orbiter processing flow at Kennedy Space Center in Florida or during Orbiter Maintenance Down Period at Palmdale, California.

Lockheed Martin Corporation produces external Tanks in the Government-Owned/Contractor-Operated (GOCO) facility near New Orleans, LA. This activity involves the following:

(1) Procurement of materials and components from vendors and production of ETs;
(2) Engineering and manufacturing personnel and necessary environmental manufacturing improvements;
(3) Support personnel and other costs to operate the GOCO facility; and
(4) Sustaining engineering for flight support and anomaly resolution.

Orbiter Maintenance Down Periods (OMDPs) occurs when an Orbiter is taken out of service periodically for detailed structural inspections and thorough testing of its systems before returning to operational status. This period also provides opportunities for major modifications and upgrades.

The Main Engine Program is managed by the Marshall Space Flight Center (MSFC) and supports the Orbiter fleet with flight-qualified main engine components and the necessary engineering and manufacturing capability to address any failure or anomaly quickly. The Rocketdyne Division of Boeing Reusable Space Systems is responsible for operating three locations that provide engine manufacturing, major overhaul, component recycle and test. They are:

(1) Canoga Park, California which manufactures and performs major overhaul to the main engines;
(2) Stennis Space Center (SSC), Mississippi for conducting engine development, acceptance and certification tests; and
(3) Kennedy Space Center (KSC), Florida where the engine inspection checkout activities are accomplished at the KSC engine shop.

The Marshall Space Flight Center (MSFC) manages engine ground test and flight data evaluation, hardware anomaly reviews and anomaly resolution. The Alternate Turbopump project is also managed by the MSFC under contract with Pratt Whitney of West Palm Beach, FL.

The Stennis Space Center (SSC) manages the SSME Test Support. This includes development, green run, and reliability demonstration (fleet leader) testing for the Space Shuttle Main engines. All engines certified for flight are tested here prior to being shipped to KSC for pre-launch processing.
The Solid Rocket Booster (SRB) project supports:

(1) Procurement of hardware and materials needed to support the flight schedule;
(2) Work at various locations throughout the country for the repair of flown components;
(3) Workforce at the prime contractor facility for integration of both used and new components into a forward and an aft assembly; and
(4) Sustaining engineering for flight support.

USA is the prime contractor on the SRB and conducts SRB retrieval, refurbishment and processing at KSC.

The Reusable Solid Rocket Motor (RSRM) project has Thiokol of Brigham City, Utah as the prime contractor for this effort. This activity involves the following:

(1) Purchase of solid rocket propellant and other materials to manufacture motors and nozzle elements;
(2) Workforce to repair and refurbish flown rocket case segments, assemble individual case segments into casting segments and other production operations including shipment to the launch site;
(3) Engineering personnel required for flight support and anomaly resolution; and
(4) New hardware to support the flight schedule required as a result of attrition.

The Vehicle and EVA project element consists of the following items and activities:

(1) Orbiter logistics: spares for the replenishment of Line Replacement Units (LRUs) and Shop Replacement Units (SRUs) along with the workforce required to support the program; procurement of liquid propellants and gases for launch and base support;
(2) Production of External Tank (ET) disconnect hardware;
(3) Flight crew equipment processing as well as flight crew equipment spares and maintenance, including hardware to support Space Shuttle extravehicular activity;
(4) The sustaining engineering associated with flight software and the Orbiter vehicles;
(5) Various Orbiter support hardware items such as Pyrotechnic-Initiated Controllers (PICs), NASA Standard Initiators (NSI's) and overhauls and repairs associated with the Remote Manipulator System (RMS); and

The major contractors for these Orbiter activities are United Space Alliance for operations; and Hamilton Sundstrand for extravehicular mobility unit (EMU) operations.

Other support requirements are also provided for in this budget, including tasks, which support flight software development and verification. The software activities include development, formulation and verification of the guidance, targeting and navigation systems software in the Orbiter.

A Safety Allocation is provided in FY 2001 to address Shuttle safety improvements through hardware/software upgrades, personnel, facility and infrastructure, or other investments. This is a significant increase over $100 million per year for Shuttle upgrades that was in previous requests. NASA has been conducting an external review to assess how the Safety Allocation funds can most effectively be used to improve safety of the Space Shuttle. NASA will proceed with upgrade activity once Authority To Proceed (ATP) has been accomplished. The highest priority safety upgrades are all part of the Flight Hardware budget element, and include the following: the Cockpit Avionics Upgrade, the Electric Auxiliary Power Unit (EAPU), and Advanced Health Monitoring for the Space Shuttle main engines (SSME). The Cockpit Avionics Upgrade, among the highest priority upgrades, is for improved avionics in the Shuttle cockpit. This will improve the situational awareness of the crew, and better equip them to handle potential flight anomalies. Additional upgrades are being assessed as part of the external review, and candidates include additional upgrades to the SSME, advanced thrust vector control for the solid rocket boosters and investments in space shuttle infrastructure and others. Prior to commitment on specific additional investments, the unspecified Safety Allocation funding is kept under Flight Hardware, although it may shift to other Space Shuttle budget elements after investment decisions are made.

SCHEDULES AND OUTPUTS

Space Shuttle Main Engine Safety Improvements - Introduction of the Block I and Block II changes into the Space Shuttle's Main Engine (SSME) program will improve the SSME margin of safety by a factor of two. The interim Block IIA configuration (Block II without the ATP High-Pressure Fuel Turbo Pump (HPFTP)) implements the safety and performance margins provided by the Large Throat Main Combustion Chamber (LTMCC) while the HPFTP development problems are solved.

High Pressure Fuel Turbopump Design Certification Review Plan: 2nd Qtr FY2001	Certifies Block II engine with alternate high pressure fuel turbopump for flight Delta DCR planned for March 2001

Global Positioning System (GPS) - GPS will replace the current TACAN navigational system in the Orbiter navigation system when the military TACAN ground stations will be phased out. The GPS certification for the Space Shuttle Operation will be completed in second quarter of FY-2002..

TACAN Removal Plan: 1st Qtr FY 2002 Revised: Under Assessment	Select flights will be flown with both systems until the GPS flight hardware is certified

Orbiter Maintenance Down Periods/Orbiter Major Modification (OMDP/OMM)

Complete Discovery (OV-103) OMDP Plan: 3rd Qtr FY 2002	Conduct routine maintenance and structural inspection. Also, install the Multifunction Electronic-Display System (MEDS) upgrade, hardware for GPS capability.

Space Shuttle Safety Allocation - New upgrades are being initiated by the Space Shuttle program to help ensure continued safe operations of the Space Shuttle by improving the margin of safety. The dates are planning estimates rather than commitments, as the program is still in an early definitional phase, but the plan is to integrate all new Space Shuttle safety upgrades across the Shuttle fleet by FY 2007. The Space Shuttle program is in the process of developing detailed project plans.

Cockpit Avionics Upgrades – This new safety upgrade improves crew situational awareness and reduces flight crew workload. It provides automated control of complex procedures and increases the level of flight crew autonomy. Functional capabilities include enhanced Caution & Warning (a system to monitor critical instrumentation parameters), abort situation monitoring and trajectory assessment, improved integrated vehicle instrumentation displays, Remote Manipulator System (RMS) safety enhancements for the robotic arm, and rendezvous and proximity operations.

Cockpit Avionics Upgrades (CAU) "Authority to Proceed" for implementation Phase Plan: 3rd Qtr FY 2001	Pending the approval of "Authority To Proceed" from NASA-Headquarters Program Management Council
CAU Preliminary Design Review Plan: 4th Qtr FY 2001 Revised: Under Review	
CAU Critical Design Review Plan: 4th Qtr FY 2002	

Electric Auxiliary Power Unit (EAPU) – Orbiter –Battery powered electric motors will replace turbines powered by hydrazine, a highly flammable and environmentally hazardous fluid. The turbines are used to drive the hydraulic pumps providing control for the orbiter such as engine movement, steering, and braking functions. The upgrade eliminates hydrazine leakage/fire hazards, eliminates turbine overspeed hazards, and reduces toxic materials processing hazards The requirement definition and system trade studies of the EAPU have been developed.

EAPU Authority to Proceed for implementation Phase Plan: 4th Qtr FY 2001 Revised: Under Review	Pending an approval of "Authority To Proceed" from NASA-HQS Program Management Council
EAPU Preliminary Design Review Plan: 3rd Qtr FY 2001 Revised: Under Review	

EAPU Critical Design Review — Completion of Critical Design Review will allow drawings to be released for production to proceed.
Plan: 2nd Qtr FY 2002
Revised: Under Review

<u>Space Shuttle Main Engine (SSME) Advanced Health Management System (AHMS)</u> - Another new safety upgrade, this project entails a suite of instrumentation, software, and computational capabilities for real-time engine assessment, rapid turnaround, and reduction in invasive, manual processing and testing. The system includes vibration monitoring, engine performance monitoring, and overall health analysis. It consists of two phases; Phase 1 reduces pump failures, Phase 2 monitors engine health and makes real time changes to increase probability of successful missions.

SSME AHM Phase I first flight
Plan: 3rd Qtr FY 2003
Revised: Under Review

SSME AHMS Phase 2
Preliminary Design Review
Plan: 1st Qtr FY 2002
Revised: Under Review

SSME AHMS Phase 2 Critical
Design Review
Plan: 4th Qtr FY 2002
Revised: Under Review

SSME AHMS Phase 2 First
flight
Plan: 1st Qtr FY 2005
Revised: Under review

<u>External Tank (ET) Friction stir weld (FSW)</u> – Provides superior welds with a highly repeatable process for the ET. 20% increase in weld strength and 95% reduction in weld repairs.

External Tank Friction Stir
Weld Critical Design Review
Plan: 3rd Qtr FY 2001

ACCOMPLISHMENTS AND PLANS

OV-104 completed two flights using the Multifunctional Electronics Display System (MEDS) that were installed in 1999. MEDS consists of eleven new full color, flat panel display screens in the cockpit replacing 32 gauges and electromechanical displays and four cathode ray tube displays. The new displays are lighter and use less power than the old configuration, and provide the pilots with easier recognition of key functions. The new cockpit will be installed in all the orbiters during their next major modification period.

OV-102 completed its major modification and structural inspection at NASA's Palmdale facilities on February 23, 2001. The major modifications performed were the installation of the multifunctional electronics display system, electrical and structural provisioning for a global positioning system, Ultra High Frequency space communication system installation, thermal protection system improvements, radiator impact protection and fluid system isolation, Orbital Maneuvering System/Reaction Control System crossfeed line hardware replacement, Orbiter docking system electrical and structural provisioning, and installation of electrical wiring protection throughout the vehicle. Additionally, this Orbiter was subjected to extensive wiring and structural corrosion inspections with repairs accomplished as needed.

Advanced air data transducer assemblies (ADTA) began flight use in FY2001 on STS-106. The ATDA are quadruple redundant sensors providing air speed and altitude data to on-board guidance and navigation systems. The advanced ATDA increases pressure measurement stability through the use of digital circuitry, eliminates costly periodic calibration, and requires no active cooling. Also making an initial flight on STS-106 was the redesigned Advanced Master Events Controller (AMEC). The AMEC replaces the Master Events Controller (MEC), and provides transfer and signal conditioning of control and measurement data between the general purpose computers, the Orbiter, External Tank, and Solid Rocket Booster pyrotechnic and control devices. The AMEC eliminates high criticality failure modes, and solves electronics parts obsolescence problems, high failure rates, and high repair turnaround times associated with the MEC.

In FY2001, the Space Shuttle Main Engine (SSME) High Pressure Fuel Turbopump/Alternate Turbopump (HPFTP/AT) program will complete certification testing and is scheduled to make its inaugural flight onboard STS-104 in the 4^{th} quarter of FY 2001. The HPFTP/AT completes the SSME hardware upgrade to the Block II configuration, adding safety to the SSME, reducing ascent risk for the Space Shuttle, and reducing the requirement for between-flight maintenance.

Authority to proceed on major flight hardware upgrades will also be determined in FY 2001. This will allow many of the proposed projects to complete their required preliminary and critical design reviews in FY 2002. Adjustments to the production of flight hardware and associated testing activity will occur in FY 2001 and FY 2002 to support a flight rate of six per year in FY 2003 and beyond.

BASIS OF FY 2002 FUNDING REQUIREMENT

GROUND OPERATIONS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Launch and Landing Operations..		523,645	539,800
Ground Operations Upgrades*..		57,873	64,300
[Checkout and Launch Control System] [included above]		[55,800]	[41,000]
Total..		581,518	604,300

* Funding for Ground Operations Upgrades is provided from the Safety Allocation and is under review pending assessment of priorities for Space Shuttle safety investments. Additional funds may be provided from Flight Hardware Upgrades pending the results of that assessment.

PROGRAM GOALS

The goal of Ground Operations is to provide safe, reliable and effective access to space. This budget is based on an average of six flights annually with a surge capability to seven flights.

STRATEGY FOR ACHIEIVING GOALS

The Ground Operations budget was previously funded in Shuttle Operations under Mission and Flight Operations and in Safety and Performance Upgrades in the Flight Operations and Launch Site Equipment upgrades.

The Ground Operations comprises most of the launch site operational facilities at KSC and their required upgrades. The major launch site operational facilities at KSC include three Orbiter Processing Facilities (OPFs), two launch pads, the Vehicle Assembly Building (VAB), the Launch Control Center (LCC) and three Mobile Launcher Platforms (MLPs). The most significant upgrade in this account is the Checkout and Launch Control System (CLCS) at KSC.

These upgrades support pre-launch and post-launch processing of the four-Orbiter fleet. Key enhancements funded in ground operations upgrades include: replacement of hydraulic pumping units that provide power to Orbiter flight systems during ground processing; replacement of 16-year old ground cooling units that support all Orbiter power-on testing; replacement of communications and tracking Ku-band radar test set for the labs in the Orbiter Processing Facility and High Bays that supports rendezvous capability and the missions; communications and instrumentation equipment modernization projects that cover the digital operational intercom system, major portions of KSC's 17-year old radio system and the operational television system; improvement of the Shuttle Operations data network that supports interconnectivity between Shuttle facilities and other KSC and off-site networks; replacement storage tanks and vessels for the propellants, pressurants and gases; an improved hazardous gas detection system; and fiber optic cabling and equipment upgrades.

The Hardware Interface Modules (HIM), which are electrical command distribution systems that support the launch processing system (LPS) at KSC, are over 25 years old and have experienced an increased failure rate and higher cost of repair over the past several years. The HIM upgrade (HIM II) replaces all chassis and cards with state-of-the-art "off-the-shelf" hardware to improve system reliability and maintainability. The production of the HIM II is complete, and installation into all launch support facilities should be completed in FY 2001.

The goal of the Operational Television System (OTV) Modernization project is to design and implement a state-of-the-art serial digital video surveillance facility that will meet the needs of the Space Shuttle Program today and through out the expected life of the program. Modernization of the Operational Television System (OTV) is based upon a phased engineering design and implementation strategy, which will enhance and automate the visual surveillance capability at KSC. A key element of the plan includes the integration of video camera operations and positioning, routing switcher, video monitoring and digital recorder control system into one unified control system (UCS) environment. The implementation of the OTV modernization project will operate concurrently with the current analog system and allow for an orderly phased transition to a completely digital video system. Other key elements of the OTV modernization project include, the upgrade from analog to digital video recorders (FY 1998), the purchase and installation of a new serial digital video routing switcher (FY 2000) and the orderly phased replacement of current analog video cameras. Due to the large number of cameras in the OTV system, the purchase and installation of new serial digital CCD cameras will be phased over a 3 to 4 year period starting FY 2001. When completed, in FY 2005, the OTV Modernization project will improve the OTV system reliability while providing the KSC Launch Team a new level of visual surveillance flexibility that promises to greatly enhance the value of the OTV system to the Shuttle program.

The Complex Control System (CCS) is used to monitor and control processing and institutional facilities systems at KSC. The obsolescence of the current CCS makes it difficult and costly to incorporate new measurements and control points as new facilities are built or existing ones are upgraded. CCS infrastructure conversion is scheduled for completion in FY 2001.

Radio Frequency (RF) communications modernization replaces the existing KSC radio communications system with a combination of digital and conventional mobile, portable and fixed stations and associated off-the-shelf equipment. RF communications modernization is scheduled for completion in FY 2001.

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50% and will provide the building blocks to support future vehicle control system requirements.

The CLCS Titan delivery will provide support for completion of development and the start of validation testing for application software used for Shuttle Orbiter power up testing. The Scout phase of CLCS is planned to support operational use in the Orbiter Processing Facility and development of Pad and launch-related application software. The Delta and Saturn phases include the completion of all launch application development, completion of software certification and validation and a complete integrated flow demonstration. . Since the FY 1999 Budget, software independent validation and verification (IV&V) performed by Ames Research Center was also added to this project.

Upgrades support pre-launch and post-launch processing of the four-Orbiter fleet. Key enhancements funded in ground operations upgrades include: replacement of hydraulic pumping units that provide power to Orbiter flight systems during ground processing; replacement of 16-year old ground cooling units that support all Orbiter power-on testing; replacement of communications and tracking Ku-band radar test set for the labs in the Orbiter Processing Facility and High Bays that supports rendezvous capability and the missions; communications and instrumentation equipment modernization projects that cover the digital operational intercom system, major portions of KSC's 17-year old radio system and the operational television system; improvement of the Shuttle Operations data network that supports interconnectivity between Shuttle facilities and other KSC and off-site networks; replacement storage tanks and vessels for the propellants, pressurants and gases; an improved hazardous gas detection system; and fiber optic cabling and equipment upgrades.

SCHEDULES AND OUTPUTS

CLCS Titan Delivery Plan: 3rd Qtr FY 2001	The Titan delivery will provide support for completion of development and the start of validation testing for application software used for Shuttle Orbiter power up testing.
CLCS Scout Delivery Plan: 3rd Qtr FY 2002	The Scout phase of CLCS is planned to support operational use in the Orbiter Processing Facility and development of Pad and launch-related application software.

ACCOMPLISHMENTS AND PLANS

Ground operations support will include launch countdown and landing for seven Shuttle missions. Ground support for Shuttle landing could include both the KSC and Edwards AFB runways. Three or four orbiters are normally in the hardware processing flow along with External Tanks, Space Shuttle Main Engines and Solid Rocket Booster components to support several missions. In FY 2001, ground operations will support the processing, checkout and testing of Shuttle hardware to support seven ISS assembly and servicing missions. Ground operations for FY 2002 also include support for seven Space Shuttle flights.
The Juno and Redstone phases of the CLCS were delivered in FY 1997. In these phases, the initial integration platform was defined, the engineering platform was installed and the interface with the math models was established. The Thor delivery was completed in FY 1998. During this phase, initial ground data bus interfaces were established and the system software was ported to the production platforms. The Atlas delivery in FY 1999 provided support for the initial applications for the Orbiter Processing Facility, the final applications for the Hypergolic Maintenance Facility (HMF), the math model validation, an interface to the Shuttle Avionics Integration Lab (SAIL) and hardware testing for SAIL. By the end of FY 2004, Operations Control Room-1 will be fully operational, followed by certification. The first Shuttle launch using the CLCS is scheduled for FY 2005 with full implementation to be completed one year later.

During FY 2000, the CLCS project was subjected to a series of independent analysis, replanning, redirection, and restructuring activities in order to address significant cost growth and schedule delays. The Space Shuttle Program (SSP) chartered an independent review team to provide recommendations for improving project performance and contractor accountability. The team briefed its recommendations in August 2000, followed by implementation direction from the SSP to the CLCS project shortly thereafter. The implemented recommendations included: establishment of a System Engineering and Integration Team that provides project-wide technical leadership and issue resolution; project restructuring that increases contractor accountability; establishment of a Project Advisory Council that enables contractor project managers to more fully participate in project-level decisions; and a review of all project processes, roles, and responsibilities. In FY 2000, the HMF CLCS set was released for operational use for testing the Forward Reaction Control System (FRCS). Additionally, in FY 2000, a CLCS hardware set was installed into the SAIL, which allows for integrated testing utilizing SAIL's full-fidelity Shuttle system model. The CLCS hardware was installed into the CLCS Control Room 1 early in FY 2001, and the Titan system software release is scheduled for later in the year; together, these hardware and software activations will allow for full application software development and validation of those applications for OPF operations. Additionally, the HMF will be fully operational for both forward and aft propulsion system operations late in 2001. In FY 2002, The Scout system software will be released, which provides the capability to execute OPF applications used for operations from the CLCS Control Room. The Scout release also allows completion of development for applications software to support VAB and Pad operations. VAB/Pad applications software can begin validation after the Scout release. A revised EAC budget and operations-capable schedule baseline was formulated and briefed to OMB in December 2000. The current cost is estimated at $398.5M. This represents an increase of $165.2M over the FY 2001 Budget to Congress estimate of $233.3M. The new launch capable date is 3rd quarter FY 2005 a delta of 37 months. The CLCS project has been executing to its new contract and structure baseline since January 1, 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

FLIGHT OPERATIONS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Mission Operations.....		199,261	194,800
Flight Crew Operations.........		62,961	62,500
Space and Life Sciences Operations....		7,783	8,100
Flight Operations Upgrades*		2,993	5,600
Total..		272,998	271,000

* Funding for Flight Operations Upgrades is provided from the Safety Allocation and is under review pending assessment of priorities for Space Shuttle safety investments. Additional funds may be provided from Flight Hardware Upgrades pending the results of that assessment.

PROGRAM GOALS

The goal of Flight Operations is to provide those services required for safe, reliable and effective access to space and to conduct on-orbit operations. This budget is based on an average of six flights annually with a surge capability to seven flights. FY 2000 had only four flights and seven flights are planned for FY 2001, and FY 2002 is a seven-flight year and includes the third Hubble Space Telescope servicing mission. The flight rate is anticipated to continue at six per year through FY 2006 as supported by this budget. Also, this manifest supports the Nation's science and technology objectives through scheduled Spacehab and other science missions and continuation of assembly and operations of the International Space Station.

STRATEGY FOR ACHIEVING GOALS

The Flight Operations budget was previously funded in Shuttle Operations under Mission and Flight Operations and in Safety and Performance Upgrades in the Flight Operations and Launch Site Equipment upgrades.

Flight Operations include a wide variety of pre-flight planning, crew training, operations control activities, flight crew operations support, aircraft maintenance and operations and life sciences operations support. The primary contractor is USA. The planning activities range from the development of operational concepts and techniques to the creation of detailed systems operational procedures and checklists. Tasks include:

(1) Flight planning;
(2) Preparing systems and software handbooks;
(3) Defining flight rules;

(4) Creating detailed crew activity plans and procedures;
(5) Updating network system requirements for each flight;
(6) Contributing to planning for the selection and operation of Space Shuttle payloads; and
(7) Preparation and plans for International Space Station assembly.

Also included are the Mission Control Center (MCC), Integrated Training Facility (ITF), Integrated Planning System (IPS) and the Software Production Facility (SPF). Except for the SPF (Space Shuttle only), these facilities integrate the mission operations requirements for both the Space Shuttle and International Space Station. Flight planning encompasses flight design, flight analysis and software activities. Both conceptual and operational flight profiles are designed for each flight and the designers also help to develop crew training simulations and flight techniques. In addition, the flight designers must develop unique, flight-dependent data for each mission. The data are stored in erasable memories located in the Orbiter, ITF Space Shuttle mission simulators and MCC computer systems. Mission operations funding also provides for the maintenance and operation of critical mission support facilities including the MCC, ITF, IPS and SPF. Finally, Mission and Crew Operations include maintenance and operations of aircraft needed for flight training and crew proficiency requirements.

Funds for other activities include implementing required modifications and upgrades on the T-38 aircraft used for space flight readiness training, capability improvements for weather prediction and enhancements on information handling to improve system monitoring, notably for anomaly tracking.

The major operations facilities at Johnson Space Center (JSC) include the Mission Control Center (MCC), the flight and ground support training facilities, the flight design systems and the training aircraft fleet that includes the Space Shuttle Training aircraft and the T-38 aircraft.

The Flight Operations budget also includes in FY 2001 and FY 2002 reimbursements that are assumed to be $4.4 million per year. These standard service reimbursements offset the total budget for the Space Shuttle and have been assumed in the NASA direct funding requirements identified above for the FY 2002 budget request

SCHEDULES AND OUTPUTS

Since the Space Shuttle program has both an operational and development component, performance measures related to the Space Shuttle program reflect a number of different activities ranging from missions planned and time on-orbit to development milestones planned for the Safety Upgrades program.

	FY 2000		FY 2001		FY 2002
Operations Metrics	Plan	Actual	Plan	Revised	Plan
Number of Space Shuttle Flights	[6]	[4]	9	7	7
Number of Days On-orbit	[61]	[41]	102	81	77
Number of Primary Payloads Flown	[6]	[2]	11	7	9

Space Shuttle Missions and Primary Payloads

FY 2001		Plan	Actual/Revised
STS-92/Discovery	Space Station #5 (ITS-Z1) (ISS-05-3A)	June 2000	October 2000
STS-97/Endeavour	Space Station #6 (PV Module) (ISS-06-4A)	July 2000	December 2000
STS-98/Atlantis	Space Station #7 (US Lab (ISS-07-5A)	August 2000	February 2001
STS-102/Discovery	Space Station #8 (MPLM-IP-01) (ISS-08-5A.1)	October 2000	March 2001
STS-100/Endeavour	Space Station #9 (MPLM-2P-01) (ISS-09-6A)	November 2000	April 2001
STS-104/Atlantis	Space Station #10 – Airlock (ISS-10-7A)	February 2001	June 2001
STS-105/Discovery	Space Station #11 (MPLM-IP-02) (ISS-11-7A.1)	March 2001	July 2001
FY 2002			
STS-108/Endeavour	Space Station #12 (MPLM) (ISS-12-UFI)	April 2001	1st Qtr FY 2002
STS-107/Columbia	Research Mission (Spacehab Double Module)	January 2001	1st Qtr FY 2002
STS-109/Columbia	Hubble Space Telescope (HST) Servicing Mission	May 2001	2nd Qtr FY 2002
STS-110/Atlantis	Space Station #13 (ITS-50) (ISS-13-8A)	June 2001	2ndt Qtr FY 2002
STS-111/Endeavour	Space Station #14 (MPLM) (ISS-14-UF2)	August 2001	2nd Qtr FY 2002
STS-112/Atlantis	Space Station #15 (ITS-51) (ISS-15-9A)	3rd Qtr FY 2002	
STS-113/Endeavour	Space Station #16 (MPLM) (ISS-16-ULFI)	4th Qtr FY 2002	

ACCOMPLISHMENTS AND PLANS

In FY 2001, seven flights are planned to be flown which are ISS assembly and servicing missions. The Shuttle program has provided launch support for space science missions accommodating universities and industry as a space laboratory and technology research vehicle. The Shuttle is also the only U.S. vehicle that provides human transportation to and from orbit. In FY 2001, 46 U.S. and international crewmembers are planned to fly approximately 540 days on-orbit, including time spent while docked the International Space Station. In FY 2002, five ISS flights are planned along with the third Hubble Space Telescope servicing mission, and a dedicated microgravity research mission.

In FY 2002 five ISS flights are planned along with a Hubble Space Telescope servicing mission, and a dedicated microgravity research mission.

BASIS OF FY 2002 FUNDING REQUIREMENT

PROGRAM INTEGRATION

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Shuttle Integration......		155,557	175,500
Program Management Support......		118,638	129,000
Facilities Construction		15,566	14,000
Program Integration Upgrades*		3,991	14,700
Total...		293.752	333,200

* Funding for Program Integration Upgrades is provided from the Safety Allocation and is under review pending assessment of priorities for Space Shuttle safety investments. Additional funds may be provided from Flight Hardware Upgrades pending the results of that assessment. This could include potential funds to address space shuttle infrastructure issues.

PROGRAM GOALS

The goal of Program Integration is to ensure the integration of the various Shuttle elements occurs successfully. Program Integration performs hundreds of modifications throughout the year related to design changes to improve reliability, supportability, or meet new program requirements. These changes are a result of hardware failures or design enhancements identified through ground checkouts or in-flight. Safety investments made to the shuttle infrastructure to ensure the continued safe operations of the Space Shuttle are funded by Program Integration Upgrades.

STRATEGY FOR ACHIEVING GOALS

The Program Integration budget was previously budgeted predominately in the Space Shuttle Operations budget under Orbiter and Integration along with the Construction of Facilities line in the Safety and Performance Upgrades budget, also some small residual funding came from other areas.

The Program Integration budget includes funds for the analysis, management, and the SRM&QA function and is performed here for the entire Space Shuttle Program. In addition, this area includes funds for the infrastructure, taxes and directly funded construction of facilities projects.

Program integration includes those elements managed by the Space Shuttle Program Office at the Johnson Space Center (JSC) and conducted primarily by United Space Alliance, including payload integration into the Space Shuttle and systems integration of the flight hardware elements through all phases of flight. Shuttle integration provides for the engineering analysis needed to ensure that various payloads can be assembled and integrated to form a viable and safe cargo for each Space Shuttle mission. Shuttle integration includes the necessary mechanical, aerodynamic and avionics engineering tasks to ensure that the launch vehicle can be safely launched, fly a safe ascent trajectory, achieve planned performance and descend to a safe landing. In addition, funding is provided for multi-program support at JSC.

Program management support is institutional and technical support provided by the centers in support of the program operations. The support covers a variety of activities ranging from electricity and roads to routine administrative support for the civil servants working on the Space Shuttle program.

Program Integration upgrades are funded from the Safety Allocation. Potential projects are under review as part of the safety investment prioritization process, and could include improvements) and other safety-related infrastructure investments.

Construction of Facilities (CofF) funding for Space Shuttle projects is provided in this budget to refurbish, modify, reclaim, replace and restore facilities at Office of Space Flight Centers to improve performance, address environmental concerns of the older facilities and to ensure their readiness to support Shuttle Operations.

SCHEDULES AND OUTPUTS

Complete Phase III of Rehabilitation of 480V Electrical Distribution System at MAF Plan: 1st Qtr FY 2001 Actual: 1st Qtr FY 2001	External Tank manufacturing building Rehabilitation of the 480V Electrical Distribution System is a 4 phase project. Each phase will be implemented in the main manufacturing areas of building 103. Project Phasing and scope for each phase: Phase III, Substations Nos. 17A/17B will replace the core system, Transformers and switch gear, breakers and oil switches. Include some down stream cable, cable tray, and panel upgrades.
Complete Phase IV of Rehabilitation of 480V Electrical Distribution System at MAF Plan: 2nd Qtr FY 2001	Phase IV, Substations Nos., 7B, 4 & 5 – core system, transformers and switchgear, breakers and oil switches.
Complete Restoration of Pad A PCR Wall and Ceiling Integrity at Launch Complex (LC)-39 Plan: 1st Qtr FY 2001	This project provides for repair and replacement of damaged Payload Change Out Room (PCR) wall panels (Sides 1, 2, 3, & 4), replacement or elimination of deteriorated and leaking access doors, and other needed replacement and restoration. The modification will eliminate degrading flexducts and filter housings, improve pressurization of the PCR, provide an even distribution of airflow, and provide safe personnel access for maintenance and repair. Additional Ceiling and wall work to be complete.

Complete Pad A Surface and Slope Restoration at LC-39 Plan: 1st Qtr FY 2001 Actual: 4th Qtr FY 2000	This project provides for initial repair of the Pad A surface concrete, pad slopes, and the crawlerway grid path. Follow on project is under review.
Complete Pad B Surface and Slope Restoration at LC-39 Plan: 2nd Qtr FY 2001 Actual: 2nd Qtr FY 2001	This project provides for initial repair of the Pad B surface concrete, pad slopes, and the crawlerway grid path. Follow on project is under review.
Complete Convoy Operations refurbishment Plan: 2nd Qtr FY 2001	This project will refurbish the SLF Convoy Operations capability at the SLF.
Complete VAB and Crawlerway Modification, LC-39 (Safe Haven) Plan: 3rd Qtr FY 2001	This project restores the crawlerway into VAB highbay 2 and provides an Orbiter towway into Highbay 4. Partial stack access will be provided for in Highbay 2 and Orbiter storage and access will be provided for in Highbay 4. This will allow use of the VAB highbays as a Safehaven during hurricanes, allow for additional manifest flexibility for stacking operations and Orbiter access operations to continue when Highbay 1 and 3 contain full stacks. All work complete on three of the four work packages. Only remaining work is electrical mods to Highbay 4
Complete Repair VAB Elevator Controls Plan: 1st Qtr FY 2002	This Project replaces the elevator systems in the Vehicle Assembly Building. The controls, cabs and cableway systems are obsolete and parts are no longer available. A recent fire in one of the VAB elevator controls caused a concern with the safety of the systems. This was identified as a safety project.
Complete Phase I Rehabilitation of A Test Stand at SSC for SSME Testing Plan: 2nd Qtr FY 2001	Phase I includes replacing structural member, rehabilitating rolling platforms level 4&5, and repair of electrical panels.
Complete Phase II Rehabilitation of A Test Stand at SSC for SSME Testing Plan: 3rd Qtr FY 2001	Phase II includes asbestos abatement, rehabilitating run tank insulation, rehabilitating shop air system, and replacement of 480 volt switchgear.

Start Phase I Restoration of Pad A Low Voltage Power System Plan: 2^{nd} Qtr FY 2001 Actual: 2^{nd} Qtr FY 2001	The restoration of the Pad A & B Low Voltage Power systems will require four (4) Phases for each Pad A&B.
Start Phase I Restoration of Pad B Low Voltage Power System Plan: 2^{nd} Qtr FY 2001 Actual: 2^{nd} Qtr FY 2001	The restoration of the Pad A & B Low Voltage Power systems will require four (4) Phases for each Pad A&B.
Start Phase II Restoration of Pad A Low Voltage Power System Plan: 2^{nd} Qtr FY 2002	
Start Phase II Restoration of Pad B Low Voltage Power System Plan: 2^{nd} Qtr FY 2002	
Start Pad A Restoration of High Pressure Distribution Piping System Plan: 1^{st} Qtr FY 2001 Actual: 1^{st} Qtr FY 2001	This project will repair or replace GN2 (6000, 3000, 750 psig), Ghe (6000, 3000, 750 psig), GO2 (6000 psig) and Breathing Air (2400 psig) high pressure tubing systems on the FSS, RSS North Bridge and lines from the Pad High Pressure Gas Storage Area. This project will not replace tubing within or downstream of user interface panels and equipment.
Start Pad B Restoration of High Pressure Distribution Piping System Plan: 1^{st} Qtr FY 2001 Actual: 1^{st} Qtr FY 2001	This project will repair or replace GN2 (6000, 3000, 750 psig), Ghe (6000, 3000, 750 psig), GO2 (6000 psig) and Breathing Air (2400 psig) high pressure tubing systems on the FSS, RSS North Bridge and lines from the Pad High Pressure Gas Storage Area. This project will not replace tubing within or downstream of user interface panels and equipment.
Start Repair and Upgrade of Substations 20A/20B Plan: 1^{st} Qtr FY 2001 Actual: 1^{st} Qtr FY 2001	This project replaces switchgear and 480V distribution system, feeders, MCC, panels, bus duct, switches in Bldg. 110, VAB, at MAF.

Completion Substations 20A/20B Plan: 2nd Qtr FY 2002	
Start Refurbish Air Pressurization System Pads A&B Plan: 4th Qtr FY 2001	This project repairs/replaces the pressurization tunnels from the Remote Air Intake Facility to the Pad Terminal Connection Room (PTCR) emergency vehicle park area. Provide drainage and lighting for the tunnels, replace pressurization fans, wiring, replace motors and dampers, air intake louvers, filters, racks, seal doors, remove asbestos.
Start Repair of the VAB Lowbay Elevator Plan: 3rd Qtr FY 2001	This project refurbishes four VAB lowbay elevators and the roof elevator. Includes replacing the motor-generator set to eliminate commutator, brush and bearing maintenance, replace relay panels.
Start Repair of Pad B Flame Deflector and Trench Plan:4th Qtr FY 2002	This project provides for repair of the fire resistant surface of the Main and SRB flame deflector, repair/replacement of damaged and corroded structural members, and repair/replacement of bricks in the Flame Trench wall.
Start Replacement of Chilled Water/Steam/Cond. System (FY 02) Phase I (110/114) Plan: 2nd Qtr FY 2002	This project replaces critical chilled water/steam/condensate systems in Building 110 and 114 at Michoud Assembly Facility (MAF). Route piping from mechanical equipment room and tank farm to north side of the VAB and to building 103 central plant mains. Replace chilled water pumps, condensate receiver stations, shutoff valves, circuit setters, strainers, control valves, etc.
Start Refurbish RSS Drive Trucks Plan: 2nd Qtr FY 2002	This project repairs or replaces the RSS Drive Trucks on each Pad. The trucks are used to retract the RSS to park position at about 18 hours before launch. Each of the two trucks consist of two right hand and two left hand bogies of two wheels each that are electric motor driven through gear box and drive train.

ACCOMPLISHMENTS AND PLANS

The Shuttle program provides cargo integration and systems integration which s required for each flight planned in FY 2001 and FY 2002. Cargo integration includes tasks to ensure cargo safety and to develop orbiter cargo interface requirements for each flight. The system integration effort encompasses System Safety and Hazard reviews, integrated avionics, and vehicle/ground integration that are required for each flight as well. In FY 2001, the Shuttle is planning seven flights - all of which are ISS assembly and servicing missions. In FY 2002, seven flights are planned - ISS will require five missions, a Hubble Space Telescope servicing mission will be performed and a dedicated microgravity research mission will be flown.

Assessment of potential infrastructure investments as part of the Safety Allocation will continue in FY 2001. Pending investment decisions, potential projects could begin in FY 2001 or FY 2002.

FY 2001 CoF funding will provide for improvements for facilities at JSC, KSC, MAF and SSC. At KSC there are 3 projects which complete the refurbishment of Pad B Payload Change Room (Wall and Ceiling), phase 1 of restoring low volt power system (Pad A and B), and the rehabilitation of high pressure distribution piping system (LC-39A/B). The JSC project repairs the roofs at Palmdale, Building 150. The SSC project modifies the A-2 Test Stand for Shuttle Testing. The MAF project repairs and upgrades the main electrical distribution system servicing the Vertical Assembly Building (110) and the Mix Room Building (130).

FY 2002 CoF funding will provide for the second Phase of the Pad A & B Low Voltage Power system refurbishment, Restoration of the Pad B Flame Deflector and Trench, Restoration of the Pad A&B RSS Drive Trucks, Third Phase of the Stennis A Stand refurbishment, and First phase of the Chilled Water/Steam/Condensator System refurbishment at MAF.

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **PAYLOAD UTILIZATION AND OPERATIONS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Payload carriers and support	49,300	[56,875]	[57,000]	HSF 3-3
Expendable launch vehicle mission support	30,600	[33,127]	[34,300]	HSF 3-5
Engineering and technical base	85,200	[73,338]	[75,200]	HSF 3-7
OSF Contributions to Academic Programs (in ETB)	(2,300)			
Total	165,100	[163,340]	[166,500]	
Distribution of Program Amount by Installation				
Johnson Space Center	27,171	[27,300]	[29,000]	
Kennedy Space Center	77,460	[86,102]	[86,774]	
Marshall Space Flight Center	44,779	[37,500]	[37,826]	
Stennis Space Center	1,586	[--]	[--]	
Ames Research Center	960	[--]	[--]	
Glenn Research Center	489	[--]	[--]	
Langley Research Center	900	[--]	[--]	
Goddard Space Flight Center	9,900	[10,900]	[11,400]	
Jet Propulsion Laboratory	635	[--]	[--]	
Headquarters	1,220	[1,538]	[1,500]	
Total	165,100	[163,340]	[166,500]	

Note -- Beginning in FY 2001, the Payload Utilization and Operations Budget Line Item (BLI) was been divided into two new budget line items - Payload and ELV Support and Investments and Support. Payload carriers and support and ELV Mission Support move to the Payload and ELV support BLI, while Engineering and Technical Base moves to the Investments and Support BLI. FY 2001 and FY 2002 data in this section are for comparison purposes only. See Payload and ELV Support and Investment and Support for more details.

PROGRAM GOALS

There are several goals in the Payload Utilization and Operations budget. They range from supporting the processing and flight of Space Shuttle payloads and NASA payloads launched from Expendable Launch Vehicles (ELV), to ensuring maximum return on the research investment, to reducing operations costs, to continuing to implement flight and ground systems improvements, and to supporting strategic investments in advanced technology needed to meet future requirements.

STRATEGY FOR ACHIEVING GOALS

The principal areas of activity in the Payload Utilization and Operations program are: 1) provide safe and efficient payload preparations and launch and landing services while reducing costs of Space Shuttle-related services; 2) provide mission planning, integration and processing for science application missions utilizing –the Multiple-Purpose Experiment Support Structures (MPESS) and payload pallets; 3) within Advanced Projects, identify and develop advanced technology to support Shuttle, International Space Station (ISS) and future Human Exploration and Development of Space programs to improve safety and reduce costs, promote space commercialization and technology transfer, and manage the agency's Orbital Debris program; and 4) within Engineering and Technical Base (ETB), empower a core workforce to operate Human Space Flight laboratories, technical facilities, and test beds, and stimulate science and technical competence in the United States. The Payload Utilization and Operations budget reflects a commitment to meet a wide array of programs. This includes Space Shuttle and science missions, flight hardware development and integration, space flight safety projects, and maintenance of an institutional base from which to perform NASA programs at reduced cost through re-engineering, consolidation and operational efficiency processes. Beginning in FY 1999, Expendable Launch Vehicle (ELV) mission support was consolidated and transferred from Earth Science and Space Science to provide more focused and efficient management of launch services to be located at the Kennedy Space Center and Cape Canaveral Air Force Base in Florida.

Beginning in FY 2001, the Payload Utilization and Operations Budget Line Item (BLI) was divided into two new budget line items - Payload and ELV Support and Investments and Support. Payload carriers and support and ELV Mission Support move to the Payload and ELV support BLI, while Engineering and Technical Base moves to the Investments and Support BLI.

BASIS OF FY 2002 FUNDING REQUIREMENT

PAYLOAD CARRIERS AND SUPPORT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Payload Carriers and Support	49,300	[56,875]	[57,000]

PROGRAM GOALS

The primary goal for Payload Carriers and Support is to safely and efficiently assemble, test, checkout, service, and integrate a wide variety of spacecraft and space experiments launched on the Space Shuttle.

STRATEGY FOR ACHIEVING GOALS

The Payload Carriers and Support program provides the technical expertise, facilities and capabilities necessary to perform payload buildup; test and checkout; integration and servicing of multiple payloads; transportation to the launch vehicle; integration and installation into the launch vehicle; post-landing retrieval, and de-integration of payloads. Operational efficiencies have been achieved that reduced processing time and error rate. Additional efficiencies under development are anticipated to further reduce cost and improve customer satisfaction.

Payload Carriers and Support also funds smaller secondary payloads like the Get-Away Specials (GAS) and Hitchhiker payloads that are managed at Goddard Space Flight Center (GSFC). The GAS payloads are research experiments that are flown in standard canisters, which can fit either on the sidewall of the cargo bay or across the bay on the GAS bridge. They are the simplest of the small payloads with limited electrical and mechanical interfaces. Approximately 158 GAS payloads have been flown. The Hitchhiker payloads are the more complex of the smaller payloads, and provide opportunities for larger, more sophisticated experiments. The Hitchhiker system employs two carrier configurations: (1) a configuration on the Orbiter payload bay sidewall and (2) a configuration across the payload bay using a Multi-Purpose Experiment Support Structure (MPESS). During the mission, the Hitchhiker payloads can be controlled and data can be received using the aft flight deck computer/standard switch panels or from the ground through the Payload Operations Control Center (POCC).

Payload analytical integration is the responsibility of the Flight Projects Directorate at the Marshall Space Flight Center (MSFC), supported by a contract with Boeing. Physical payload integration and processing is the responsibility of the Space Station and Shuttle Payloads Directorate at the KSC, also supported by a contract with Boeing.

Another item funded in Payload Carriers and Support is the Flight Support System (FSS) at the Goddard Space Flight Center. The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS is used on the Hubble Space Telescope (HST) repair/revisit missions.

SCHEDULES AND OUTPUTS

	FY 2000		FY 2001		FY 2002
Missions Supported	Plan	Actual	Plan	Revised	Plan
Space Shuttle Missions	6	4	[9]	[7]	[7]
Hitchhiker Experiments, includes CAP/SEM/HH Jr.	2	3	[7]	[6]	[2]
Get-Away Special Payloads	--	1	[2]	[2]	[8]
Spacehab Missions	1	2	[1]	[1]	[--]
Other Major Payloads	11	4	[13]	[20]	[13]
Other Secondary Payloads	6	8	[1]	[8]	[2]
Multi-Purpose Experiment Support Structure (MPESS) Pallets	3	3	[5]	4]	[3]
Number of Payload Facilities Operating at KSC	5	5	[5]	[6]	[5]
KSC Payload Ground Operations (PGOC) Workforce	308	258	[334]	[302]	[322]

ACCOMPLISHMENTS AND PLANS

During FY 2000, Payload Carriers and Support provided the FSS and a pallet, integration and testing support activities for Hubble Space Telescope (HST) Servicing Mission 3A, a pallet, integration and testing support activities in support of the Shuttle Radar Topography Mission (STRM), and a pallet in preparation for one ISS assembly flight. Launch and landing payload support activities were provided for four Space Shuttle missions, encompassing payload processing support activities and facilities for six major payloads, including two ISS assembly and utilization flights. A number of secondary payloads were also supported. Funding also included the planning and processing of payloads in support of the Space Shuttle and ELV manifests; and provided operations and maintenance (O&M) of five Payload Facilities at KSC. In order to fund the requirements of payload processing for the HST Servicing Mission added in FY 2000, NASA has placed the Vertical Processing Facility (VPF) at KSC in a stand-by mode. While there are no current requirements in the Shuttle manifest for the unique capabilities of the VPF, the VPF is the only vertical integration facility for Shuttle payloads as well as the only location with hazardous Cargo Integration Test Equipment (CITE) capabilities. This could have potential impact on processing some payloads due to conflicts in remaining facilities. Reimbursable funds of $1,125,000 were received in FY 2000 to cover processing costs for GAS and Hitchhiker payloads.

Beginning in FY 2001, the Payload Carriers and Support budget was transferred to a new budget line item called Payload and ELV Support. Details on FY 2001 and FY 2002 activity can be found in this section.

BASIS OF FY 2002 FUNDING REQUIREMENT

EXPENDABLE LAUNCH VEHICLE SUPPORT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Expendable Launch Vehicle Support	30,600	[33,127]	[34,300]

PROGRAM GOALS

The goals of the Expendable Launch Vehicle (ELV) mission support program are: (1) enhance probability of mission success and on-time cost effective launch services for NASA missions undertaken in support of NASA's strategic plan; (2) provide comprehensive advanced mission analysis and feasibility assessments for NASA payload customers; (3) increase efficiency in launch site operations and countdown management; and (4) provide low-cost secondary payload opportunities.

STRATEGY FOR ACHIEVING GOALS

NASA has consolidated ELV management and acquisition of launch services at Kennedy Space Center (KSC). Effective in FY 1999, all funding for mission support was transitioned from the Office of Space Science and the Office of Earth Science to the Office of Space Flight, consistent with assignment of responsibility for ELV management to OSF.

KSC is responsible for acquiring requisite launch services to meet all Enterprise requirements and for increasing the probability of mission success through focused technical oversight of commercially provided launch services. A core team of civil servants and contractors primarily located at KSC performs the technical management. KSC personnel are also resident at key launch sites, launch facilities and customer facilities. NASA personnel are resident at Vandenberg AFB in California where all launches into a polar orbit, such as those required by the Earth Science Enterprise, are conducted. Resident office personnel are located in launch service contractor plants, specifically, the Lockheed Martin Corporation Atlas Centaur plant in Denver and the Boeing Corporation Delta plant in Huntington Beach, California. KSC customer offices have been established at GSFC and JPL as the centers assigned program management responsibility for the majority of Space Science and Earth Science missions requiring access to space via NASA-provided launch services.

Advanced mission design/analysis and leading edge integration services are provided for the full range of NASA missions under consideration for launch on ELV's. Technical launch vehicle support is provided in the development and evaluation of spacecraft Announcement of Opportunities, to enable cost effective consideration of launch service options and technical compatibility. Early definition of vehicle requirements enables smooth transition to launch service and an excellent cost containment strategy.

Launch site operations and countdown management is being improved through the use of a consolidated launch team, efficient telemetry systems, and close partnership with Boeing and the USAF to assure lowest cost west coast Delta launch complex operations.

NASA's ELV secondary payload program enables efficient use of excess vehicle performance on selected NASA, USAF and commercial missions through funding integration of small secondary payloads. These payloads are sponsored by university research institutions and often international cooperatives which can take advantage of available limited excess space and performance on launch vehicles and accept the primary payload's launch schedule and orbit. NASA has developed a standard Delta secondary launch vehicle capability and has similar discussions under way with other US ELV providers.

SCHEDULES AND OUTPUTS

	FY 2000		FY 2001		FY 2002
Missions Supported	Plan	Actual	Plan	Revised	Plan
Primary ELV Missions	9	6	[11]	[10]	[8]
Secondary ELV Payloads	5	1	[1]	[2]	[1]
Total Missions Supported	14	7	[12]	[12]	[9]

ACCOMPLISHMENTS AND PLANS

During FY 2000, six ELVs were successfully launched (SWAS, Deepspace, Mars Orbiter, Mars Lander, Stardust, Landsat 7, FUSE, WIRE, Terriers, QuikScat) and three were delayed by contractor failure investigation activities until FY 2001 (TDRS-H, TERRA, and GOES-L). One secondary payload was launched (ORSTED/SUNSAT) and two secondaries (Munin/CE) were delayed due to the readiness of the primary spacecraft. The modification/rehabilitation project of the Engineering and Operations Building located on Cape Canaveral Air Station, Florida, was completed. Installation of a backup power supply system located at Vandenberg Launch Site Complex 2 (SLC-2) at Vandenberg Air Force Base (VAFB), California, was also completed.

In FY 2000, the NASA Launch Services (NLS) procurement for purchasing launch services for future NASA missions – including potential Space Station re-supply missions was competed. This contract provided for awards to multiple contractors with vehicles with demonstrated flight history.

Beginning in FY 2001, the ELV Mission Support budget will be in a new budget line item called Payload and ELV Support. Details on FY 2001 and FY 2002 activity can be found in this section.

BASIS OF FY 2002 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Engineering and technical base	85,200	[73,338]	[75,200]

PROGRAM GOALS

The focus of the Engineering and Technical Base (ETB) is to support the institutional capability in the operation of space flight laboratories, technical facilities, and testbeds; to conduct independent safety, and reliability assessments; and to stimulate science and technical competence in the United States. ETB activities are carried out at the Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and Stennis Space Center (SSC). ETB funds are used to: maintain the Centers' technical competence and ability to perform research; conduct analysis and testing tasks; solve present problems; and to reduce costs in developing programs, technologies, and materials. Efforts include system and mission analysis, integrated HSF Research and Technology (R&T) requirements definition and integration, modest R&T investments in an EVA technology demonstration project and investments in R&T required for supporting the integrated Office of Space Science/HEDS robotic efforts.

STRATEGY FOR ACHIEVING GOALS

The complex and technically challenging programs managed by the Office of Space Flight (OSF), now and in the future, are most effectively carried out by sustaining a NASA "core" institutional technical base. It is vital to preserve essential competency and excellence. Since FY 1994, the OSF centers have consolidated activities and have identified ways to economize the resources committed to ETB while maintaining ETB's benefits to the nation's human space flight program. Over the next few years, this consolidation will continue to generate savings through improved information resources management and contract streamlining. A prioritized core capability will include multi-program labs and test facilities, associated systems, equipment, and a full range of skills capable of meeting research, testing and simulation demands.

As the ETB budget is reduced, several activities will continue to refine current business practices. Mandatory equipment repair and replacement will be reassessed. Software applications for multi-program analytical tools will be implemented. The strategy to better manage the NASA investment in information processing resources includes aggressive actions to integrate and consolidate more ADP operations. ETB will ensure synergism among major NASA engineering programs. Awards for education and research tasks will be granted to support educational excellence and research learning opportunities in colleges and universities. A key challenge of the ETB strategy will be to provide a core capability for future human space flight endeavors with fewer resources. Adoption of new innovative processes to meet critical ETB core requirements and streamlining or eliminating non-critical capabilities will enable future savings.

In the FY 2001 budget, funding for Engineering and Technical Base was moved from the Payload Utilization and Operations budget line item to a new budget line item, Investments and Support.

SCHEDULES AND OUTPUTS

Laboratories & facilities supported (KSC)	Maintains 11 science and engineering laboratories in support of 6 agency programs
Laboratories & facilities supported (JSC)	Maintains 156 science and engineering laboratories in support of 52 agency programs
Laboratories & facilities supported (MSFC)	Maintains 123 science and engineering laboratories and facilities in support of 42 agency programs
Laboratories & facilities supported (SSC)	Maintains 3 science and engineering laboratories in support of 2 agency programs
NASA Minority University Research and Education Program at JSC, KSC, MSFC & SSC	Award education and research grants

ACCOMPLISHMENTS AND PLANS

In FY 2000, ETB continued to provide vital support to JSC, KSC, SSC, and MSFC science and engineering lab infrastructure to meet many critical programmatic milestones that require extensive support from these labs. NASA performed many critical studies, tests, and analyses for many activities. These included: monitoring human life support and crew health as crews begin to inhabit the International Space Station; ensuring the Space Shuttle can safely operate and transport Station hardware and astronaut personnel; and ensuring smooth and safe operations of personnel and equipment during the Station assembly EVAs. In addition, ETB will keep our labs operational to perform exploration and development studies.

The Engineering and Technical Base also supports Information Resource Management (IRM). IRM processing achieved efficiencies and improved economies of scale through the consolidation of IBM-compatible mainframes supporting administrative and programmatic automated data processing (ADP) services at the NASA ADP Consolidation Center (NACC) located at MSFC. The NACC continues to seek new and innovative ways to achieve cost savings. Since 1994, the NACC has provided supercomputing capability for its customers for engineering and scientific computer-intensive applications seven days a week. The NACC supercomputing facility includes a mainframe located at MSFC and a smaller distributed system located at JSC, supporting customers at both Centers. The NACC supercomputer facilities include hardware and software to conduct thermal radiation analyses, computational fluid dynamics, structural dynamics and stress analyses for NASA programs such as the Space Shuttle, X-33, X-34, Space Station, and Reusable Launch Vehicle. The facilities also conduct certification and engineering performance evaluation of flight and test data.

In FY 2000, there was an effort to include systems analysis and modest investments in research and technology to meet long-term HSF requirements included in the ETB budget. The In-House HEDS Studies for FY2000 addressed systems definition and analysis, and technology road map definition for a wide variety of potential options for future HEDS programs to improve safety and reduce costs; to promote space commercialization and technology transfer; and to enable future missions. These studies were closely integrated with agency next decade planning activities and the HEDS Technology/Commercialization initiative started in FY 2001. Systems Analysis will provide for overall planning and analysis for development of new technology, focusing on innovative, high-leverage technologies and approaches which will enable the development of new capabilities to meet future human space flight needs, and providing the opportunity for enhanced synergy between ongoing programs and future HEDS objectives. Studies included the following activities:

- Overall integration and development of technical requirements, technology roadmaps, and investment strategies;
- Evaluation of alternative mission approaches and technologies;
- Development of advanced transportation system architectures and technology requirements;
- Definition of R&T for Advanced Power, Information Systems Technology, and Advanced Sensors;
- System & concept definition and identification of proof-of-concept tests/ demonstrations for key emerging HEDS technologies/systems;
- ISS evolution systems analysis to determine far-term mission requirements and concepts for cost reduction and performance enhancement; and
- Identification of candidate HEDS payloads for future Mars robotics missions providing low cost environmental data and technology demonstrations that are necessary to enable safe exploration missions in the future.

In FY 2000, ETB continued to provide vital support to JSC science and engineering lab infrastructure. FY 2000 contained many critical programmatic milestones that required extensive support from our labs. NASA performed many critical studies, tests, and analyses for many activities. These included: monitoring human life support and crew health as we inhabited Station in FY 2000; and ensuring the Shuttle could safely operate and transport Station hardware and astronaut personnel; ensuring smooth and safe operations of personnel and equipment during the Station assembly EVAs. In addition, ETB kept our labs operational to perform exploration and development studies.

In cooperation with the goals of the NASA Minority University Research and Education Program, ETB enabled the Space Flight Centers to participate in programs to stimulate science and technical competence in the nation. The ETB program enabled the Centers to award education and research grants to Historically Black Colleges and Universities (HBCU). Examples include: solution crystal growth in low gravity; organic fiber optic sensors; hydrology, soil climatology, and remote sensing; and cytogenic investigations into radiosensitivity, genetic instability and neoplasti. JSC awarded approximately $1.0 million in new research grants to Historically Black Colleges and Universities and Other Minority Universities. MSFC, KSC and SSC also participated in programs to stimulate science and technical competence by participating in education and research grants with Historically Black

Colleges and Universities (HBCU) and Other Minority Universities (OMUs). Beginning in FY 2001. This activity was removed from the ETB program and consolidated with other Office of Space Flight contributions to academic programs in a single project.

In FY 2000 the ETB budget continued to implement the Agency's Zero-Base Review (ZBR) recommendations. These include a reduced level of science and engineering lab support to human space flight programs, streamlined technical operations, additional ADP consolidation activities, and reduced education and research awards funding. These reductions required that all Centers continue to assess their range of workforce skills, analytical tools and facilities dedicated to ensure their ability to provide space flight institutional engineering support for future human space flight programs and the existing customer base. Center assessments focused on maintaining core support for design, development, test and evaluations, independent assessments, simulation, operations support, anomaly resolution, and systems engineering activities.

Beginning in FY 2001, the Engineering and Technical Base budget was moved to a new budget line item called Investments and Support. Details on FY 2001 and FY 2002 activity can be found in this section.

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **PAYLOAD AND ELV SUPPORT**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Payload Carriers and Support	[49,300]	56,875	57,000	HSF 4-3
Expendable Launch Vehicle Mission Support	[30,600]	33,127	34,300	HSF 4-6
Total	[79,900]	90,002	91,300	
Distribution of Program Amount by Installation				
Johnson Space Center	[1,300]	1,300	1,300	
Kennedy Space Center	[64,802]	74,502	75,174	
Marshall Space Flight Center	[3,800]	3,300	3,426	
Glenn Research Center	[139]	--	--	
Goddard Space Flight Center	[9,824]	10,900	11,400	
Jet Propulsion Laboratory	[35]	--	--	
Total	[79,900]	90,002	91,300	

Note: Both of these projects were previously funded in the Payload Utilization and Operations budget line item in FY 2000. Beginning in FY 2001, these projects are funded from this budget line item.

PROGRAM GOALS

The Payload and ELV Support comprises two programs: Payload Carriers and Support and Expendable Launch Vehicle (ELV) Mission Support. Payload Carriers and Support provides technical expertise, facilities, flight carrier hardware and capabilities necessary to perform payload buildup; test and checkout; integration and servicing of multiple payloads; transportation to the Space Shuttle; integration and installation into the Space Shuttle; post landing retrieval and de-integration of payloads.

Expendable Launch Vehicle (ELV) Mission Support has four goals. They are: (1) enhance probability of mission success and on-time cost effective launch services for NASA missions undertaken in support of NASA's strategic plan; (2) provide comprehensive advanced mission analysis and feasibility assessments for NASA payload customers; (3) increase efficiency in launch site operations and countdown management; and (4) provide low-cost secondary payload opportunities.

STRATEGY FOR ACHIEVING GOALS

The principal areas of activity in the Payload and ELV Support programs are: 1) provide safe and efficient payload preparations and launch and landing services while reducing costs of Space Shuttle and ELV-related services; and 2) provide mission planning, integration and processing for science application missions.

The Payload and ELV Support budget reflects a commitment to accommodate a wide array of projects ranging from science missions, flight hardware development and integration, and space flight safety projects. It also maintains an institutional base from which to perform NASA programs at reduced cost through re-engineering, consolidation and operational efficiency processes.

BASIS OF FY 2002 FUNDING REQUIREMENT

PAYLOAD CARRIERS AND SUPPORT

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Payload Carriers and Support	[49,300]	56,875	57,000

PROGRAM GOALS

The primary goal for Payload Carriers and Support is to safely and efficiently assemble, test, checkout, service, and integrate a wide variety of Space Shuttle spacecraft and space experiments.

STRATEGY FOR ACHIEVING GOALS

The Payload Carriers and Support program provides the technical expertise, facilities and capabilities necessary to perform payload buildup; test and checkout; integration and servicing of multiple payloads; transportation to the launch vehicle; integration and installation into the launch vehicle; post-landing retrieval, and de-integration of payloads. Operational efficiencies have been achieved that reduced processing time and error rate. Additional efficiencies under development are anticipated to further reduce cost and improve customer satisfaction.

Payload Carriers and Support also funds smaller secondary payloads like the Get-Away Specials (GAS) and Hitchhiker payloads that are managed at Goddard Space Flight Center (GSFC). The GAS payloads are research experiments that are flown in standard canisters, which can fit either on the sidewall of the cargo bay or across the bay on the GAS bridge. They are the simplest of the small payloads with limited electrical and mechanical interfaces. Approximately 158 GAS payloads have been flown. The Hitchhiker payloads are the more complex of the smaller payloads, and provide opportunities for larger, more sophisticated experiments. The Hitchhiker system employs two carrier configurations: (1) a configuration on the Orbiter payload bay sidewall and (2) a configuration across the payload bay using a Multi-Purpose Experiment Support Structure (MPESS). During the mission, the Hitchhiker payloads can be controlled and data can be received using the aft flight deck computer/standard switch panels or from the ground through the Payload Operations Control Center (POCC).

Payload analytical integration is the responsibility of the Flight Projects Directorate at the Marshall Space Flight Center (MSFC), supported by a contract with Boeing. Physical payload integration and processing is the responsibility of the Space Station and Shuttle Payloads Directorate at the KSC, also supported by a contract with Boeing.

Another item funded in Payload Carriers and Support is the Flight Support System (FSS) at the Goddard Space Flight Center. The FSS consists of three standard cradles with berthing and pointing systems along with avionics. It is used for on-orbit maintenance, repair, and retrieval of spacecraft. The FSS is used on the Hubble Space Telescope (HST) repair/revisit missions.

MEASURES OF PERFORMANCE

	FY 2000		FY 2001		FY 2002
Missions Supported	Plan	Actual	Plan	Revised	Plan
Space Shuttle Missions	[6]	[4]	9	7	7
Hitchhiker Experiments, includes CAP/SEM/HH Jr.	[2]	[3]	7	6	2
Get-Away Special Payloads	[0]	[1]	2	2	8
Spacehab Missions	[1]	[2]	1	1	0
Other Major Payloads	[6]	[4]	13	20	13
Other Secondary Payloads	[7]	[8]	1	8	2
Multi-Purpose Experiment Support Structure (MPESS) Pallets	[3]	[3]	5	4	3
Number of Payload Facilities Operating at KSC	[5]	[5]	5	6	5
KSC Payload Ground Operations (PGOC) Workforce	[308]	[258]	334	302	322

ACCOMPLISHMENTS AND PLANS

Prior to FY 2001, the Payload Carriers and Support budget was contained in the Payload Utilization and Operations budget line item. Details on FY 2000 activity can be found in this section.

In FY 2001, Payload Carriers and Support will provide the FSS and a pallet, integration and testing support activities in preparation for HST Servicing Mission 3B. Launch and landing payload support activities include eight planned Space Shuttle Missions, encompassing payload processing support activities and facilities for 20 major payloads, including seven ISS assembly and utilization flights. A number of secondary payloads will also be supported. A Multi-Purpose Experiment Support Structure was modified to better utilize available volume of the Space Shuttle Payload Bay for scientific secondary payloads and to support ISS Launch-on-Need requirements. O&M of Payload Facilities at KSC is provided. The Vertical Processing Facility will remain closed until needed later in the year for payload processing to support the HST Servicing Mission 3B. After HST 3B requirements are fulfilled, further utilization of the VPF will be reviewed. Funding includes Construction of Facility funding in the amount of $200,000 for facility planning and design for future projects. It is planned that reimbursable funds of $1,059,000 will be received in FY 2001 to cover processing costs for GAS and Hitchhiker payloads.

In FY 2002, Payload Carriers and Support will provide the FSS and a pallet, integration and testing support activities for HST Servicing Mission 3B. Launch and landing payload support activities include 7 planned Space Shuttle Missions, encompassing payload processing support activities and facilities for 13 major payloads, including 5 ISS assembly and utilization flights. A number of secondary payloads and ISS Launch- on-Need ORUs will also be supported. Operations and maintenance of payload facilities at KSC will be provided. Funding includes a Construction of Facility project in the amount of $750,000 for repair and modernized Heating Ventilation and Air Condition (HVAC) for the Payload Hazardous Support Facility (PHSF), Building M7-1354 and an additional $100,000 is for facility planning and design for future projects.

BASIS OF FY 2002 FUNDING REQUIREMENT

EXPENDABLE LAUNCH VEHICLE SUPPORT

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Expendable Launch Vehicle Support	[30,600]	33,127	34,300

PROGRAM GOALS

The goals of the Expendable Launch Vehicle (ELV) mission support program are to: (1) enhance probability of mission success and on-time cost effective launch services for NASA missions undertaken in support of NASA's strategic plan; (2) provide comprehensive advanced mission analysis and feasibility assessments for NASA payload customers; (3) increase efficiency in launch site operations and countdown management; and (4) provide low-cost secondary payload opportunities.

STRATEGY FOR ACHIEVING GOALS

In FY 1999, NASA consolidated ELV management and acquisition of launch services at Kennedy Space Center (KSC). KSC is responsible for acquiring requisite launch services to meet all Enterprise requirements and for increasing the probability of mission success through focused technical oversight of commercially provided launch services. A core team of civil servants and contractors primarily located at KSC performs the technical management. KSC personnel are also resident at key launch sites, launch facilities and customer facilities. NASA personnel are resident at Vandenberg AFB in California where all launches into a polar orbit, such as those required by the Earth Science Enterprise, are conducted. Resident office personnel are located in launch service contractor plants, specifically, the Lockheed Martin Corporation Atlas Centaur plant in Denver and the Boeing Corporation Delta plant in Huntington Beach, California. KSC customer offices have been established at GSFC and JPL as the centers assigned program management responsibility for the majority of Space Science and Earth Science missions requiring access to space via NASA-provided launch services.

Advanced mission design/analysis and leading edge integration services are provided for the full range of NASA missions under consideration for launch on ELV's. Technical launch vehicle support is provided in the development and evaluation of spacecraft Announcement of Opportunities, to enable cost effective consideration of launch service options and technical compatibility. Early definition of vehicle requirements enables smooth transition to launch service and an excellent cost containment strategy.

Launch site operations and countdown management is being improved through the use of a consolidated launch team, efficient telemetry systems, and close partnership with Boeing and the USAF to assure lowest cost west coast Delta launch complex operations.

NASA's ELV secondary payload program enables efficient use of excess vehicle performance on selected NASA, USAF and commercial missions through funding integration of small secondary payloads. These payloads are sponsored by university research institutions and often international cooperatives which can take advantage of available limited excess space and performance on launch vehicles and accept the primary payload's launch schedule and orbit. NASA has developed a standard Delta secondary launch vehicle capability and has similar discussions under way with other US ELV providers.

MEASURES OF PERFORMANCE

	FY 2000		FY 2001		FY 2002
Missions Supported	Plan	Actual	Plan	Revised	Plan
Primary ELV Missions	[9]	[6]	11	10	8
Secondary ELV Payloads	[5]	[1]	1	2	1
Total Missions Supported	[14]	[7]	12	12	9

ACCOMPLISHMENTS AND PLANS

The ELV Sustaining effort will support launch site maintenance and sustaining operations at Vandenberg AFB and Cape Canaveral Air Station. It will also support technical insight across all launch vehicle classes (Small, Med-Lite, Medium, Intermediate and NLS). Support is also included for 10 primary payload missions (including HETE-II, EO-1/SAC-C, HESSI, GENESIS, Odyssey, TIMED/JASON, GOES–M, MAP, AQUA, Kodiak Star) and 2 secondary payloads (QUIKTOMS, PROSEDS) to be launched in FY 2001. In addition, support for 8 primary payload missions (including NOAA-M, GALEX, ICESAT/CATSAT, SCISAT, SORCE, CONTOUR, SIRTF, TDRS-I) and 1 secondary payload (CHIPS) to be launched in FY2002. This also supports the assessment of necessary modification and/or replacement of the NASA Operations Center at Vandenberg Air Force Base, CA.

In FY 2000, the NASA Launch Services (NLS) procurement for purchasing launch services for future NASA missions – including potential Space Station re-supply missions was competed. This contract provided for awards to multiple contractors with vehicles with demonstrated flight history. Two additional competitions are supported in this request. In FY2001/FY2002, the Next Generation Launch Services (NGLS) contracts will be competed. Next Generation Launch Services (NGLS) will enable emerging launch services companies, with little or no flight history, to compete for offering launch services to NASA. A Procurement Development Team (PDT)/Source Evaluation Board (SEB) was formed to compete the new Mission Support contract for ELV Integrated Services (ELVIS).

The NLS and NGLS procurements, in addition to the existing Small ELV (SELV) contracts will be used for the Alternative Access element of the Space Launch Initiative, for which funding began in FY 2001 in the SAT account. Alternative Access funding is intended to enable NASA to establish and use alternative means of access to the International Space Station. These funds will be used to purchase services, however, in the near-term they may support technology development or operational technology demonstrations to help enable near term commercial launch systems that could service space station. Alternative access could provide important benefits, including contingency capability, operational flexibility, increased competition, near-term flight opportunities, and development of capabilities to meet station-unique needs. The OSF ELV Program will continue to work closely with OAST on Alternative Access and NASA envisions that funding for Alternative Access may be transferred from the SAT account to the HSF account in the future.

FY2001 funding includes construction of facility funding of $200,000 for facility planning and design for future projects. FY 2002 funding includes two construction of facility projects totaling, $1,950,000: (1) Modernize Launch Vehicle Data Center at Vandenburg Air Force Base, CA in the amount of $1,200,000 and (2) Upgrade Mobile Service Tower and Pad Lighting, at the Vandenburg Launch Site Space Launch Complex-2 in the amount of $750,000. It is planned that reimbursable funds of $9,559,000 will be received in FY 2001 to cover processing costs for the Picosat payloads to be flown on an Athena-1 launch vehicle and $571,000 will be received in FY 2002 to cover processing costs for secondary payloads.

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — **INVESTMENTS AND SUPPORT**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Rocket Propulsion Test Support		27,938	27,800	HSF 5-3
OSF Contributions to Academic Programs		7,982	--	HSF 5-9
Technology and Commercialization		19,956	19,000	HSF 5-11
Engineering and Technical Base		73,338	75,200	HSF 5-14
HEDS Institutional Support		--	1,181,500	HSF 5-17
Total		129,214	1,303,500	
Distribution of Program Amount by Installation				
Johnson Space Center		33,170	408,306	
Kennedy Space Center		11,750	279,055	
Marshall Space Flight Center		38,438	259,627	
Stennis Space Center		20,101	52,742	
Ames Research Center		100	16,846	
Dryden Flight Research Center			13,865	
Glenn Research Center		1,800	55,742	
Langley Research Center		650	10,520	
Goddard Space Flight Center		3,005	57,430	
Jet Propulsion Laboratory		850	11,357	
Headquarters		19,350	138,010	
Total		129,214	1,303,500	

PROGRAM GOALS

The Investments and Support budget provides resources to support a wide range of activity including the maintenance and modernization of NASA's rocket propulsion test facilities, support for NASA's academic programs, research investments in the Human Exploration and Development of Space (HEDS) enterprise through the HEDS Technology and Commercialization Initiative, and Engineering and Technical Base (ETB). Agency investments in these strategic areas are essential to ensure maximum return on research investments, thereby reducing operations costs and continuing to implement flight and ground systems improvements, and to support strategic investments in advanced technology needed to meet future requirements and enabling synergistic commercial space development efforts.

STRATEGY FOR ACHIEVING GOALS

The Investments and Support budget reflects a commitment to meet a wide array of programs. The principal areas of activity in the Investments and Support program are:

1) To provide leadership in the area of rocket propulsion testing;
2) To develop technologies to enable future space exploration activities and promote space commercialization and technology transfer; and
3) To empower a core workforce to operate Human Space Flight laboratories, technical facilities, and test beds, and stimulate science and technical competence in the United States.

The Investments and Support budget was a new budget line item established in the FY 2001 budget. Funding for this budget line, with the exception of the HEDS Technology and Commercialization program, was established from programs previously funded in the Human Space Flight and Mission Support Appropriations. Specifically, the Engineering and Technical Base was previously funded from the Payload Utilization and Operations budget line item in FY 1999 and FY 2000. The Enterprise Contribution to Academic Programs was previously funded from both Space Shuttle and Payload Utilization and Operations. The Rocket Propulsion Test Program was previously funded in the following BLIs: Space Shuttle, Engineering and Technical Base, Space Station and Research and Program Management (R&PM). Beginning in FY 2002, the budget for additional support to NASA's academic programs was transferred to the Academic programs to centralize agency funding for this activity.

BASIS OF FY 2002 FUNDING REQUIREMENT

ROCKET PROPULSION TEST SUPPORT

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Rocket Propulsion Test Support	[24,500]	27,938	27,800

PROGRAM GOALS

A new Budget Line Item (BLI) was established in FY 2001 to ensure NASA's rocket propulsion test capabilities are properly managed and maintained in world class condition. The Rocket Propulsion Test Support Program is a consolidation of ongoing activities to achieve a more effective test program. The Rocket Propulsion Test Support Program was previously funded in FY 2000 and prior years in the following BLIs: Space Shuttle, Engineering and Technical Base (ETB) and Research and Program Management (R&PM). This consolidation has significantly enhanced NASA's ability to properly manage rocket testing activities and infrastructure.

STRATEGY FOR ACHIEVING GOALS

The Stennis Space Center (SSC) has been appointed as Lead Center for Propulsion Testing to manage this initiative, which includes making test assignments and approval of test facility investments. Funding for this program provides:

1) sustaining support for propulsion test facilities which include test positions and related infrastructure at SSC, JSC-WSTF, GRC-PB and MSFC;
2) modernization/upgrades of existing facilities to ensure their capabilities are adequate to meet the demands of our future customers and to optimize their operating efficiency;
3) administrative/technical support to SSC for scheduling and management of propulsion testing across the agency and coordination of these activities with DoD and commercial customers; and
4) development of test technologies to improve analytical capabilities, hardware health monitoring, and operational safety and achieve cost savings through enhanced operational efficiencies.

NASA has established a Rocket Propulsion Test Management Board (RPTMB) under Stennis Space Center's purview, which is NASA's Lead Center for Rocket Propulsion Testing. The RPTMB is composed of representatives from all four NASA rocket test centers (SSC, MSFC, JSC-White Sands and GRC-Plum Brook) and is chaired by SSC. The RPTMB has established baseline test roles for each center, resulting in the consolidation of test capabilities and the elimination of redundant facilities and related infrastructure. The roles are tailored to take advantage of existing unique capabilities at each site and to consolidate capabilities where appropriate. The RPTMB makes test assignments, controls investments, and manages personnel and equipment sharing among NASA's test sites.

In addition, NASA has been key to the formation and development of the National Rocket Propulsion Test Alliance (NRPTA). NASA and DoD test sites are cooperating to share people and equipment, review/track investments, and make interagency test assignments that will improve test support and avoid redundant investments in federally owned and operated test facilities. The NRPTA maintains an integrated national rocket test facility schedule and utilization rate, along with detailed data on NASA/DoD test facility capabilities.

SCHEDULE AND OUTPUTS

Improve test capabilities and increase safety through modernization/upgrades of test facilities at all NASA test centers

Improve altitude system capability and efficiency Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Improve altitude system capability and efficiency at JSC-WSTF and GRC-PB. Installed vacuum isolation valves and high speed safety valves at JSC-WSTF and completed refurbishment of cooling water system for B-2 test stand at Glenn research Center - Plumbrook Complex (GRC-PB)
High-pressure spares and equipment upgrades Plan: 3rd Qtr FY 2000 Actual: 3rd Qtr FY 2000	Provide critical high-pressure spares and equipment upgrades for E Complex at Stennis Space Center (SSC). Spare hardware procurements implemented in FY 00; additional acquisitions/upgrades planned in FY 2001-2002
Data Acquisition and Control Systems (DACS) and video systems upgrades Plan: 3rd Qtr FY 2001	Install Data Acquisition and Control Systems (DACS) and video systems upgrades at E3 test facility at SSC.
Refurbish spray chamber water system Plan: 4th Qtr FY 2001	Refurbish spray chamber water system for B-2 test stand at GRC/PB
Liquid Nitrogen (N2) system upgrades Plan: 4th Qtr FY 2001	Complete Liquid Nitrogen (N2) system upgrades for Propulsion Test Area at White Sands Test Facility (WSTF)
Repair structural support systems Plan: 4th Qtr FY 2001	Repair structural support systems/install enhanced N2 storage capability at Test Stand 115 at Marshall Space Flight Center (MSFC)

Activate new Data Acquisition and Control System Lab (DACS) Plan: 1st Qtr FY 2002	Complete activation and operational deployment of new DACS lab in Bldg. 4010 at SSC.
Initiate replacement of steam boilers Plan: 1st Qtr FY 2002	Initiate replacement of steam boilers for alt exhaust system in B2 at GRC/PB.
Initiate repair and activation of TS 4670 Plan: 1st Qtr FY 2002	Initiate repair and activation of Test Stand 4670 at MSFC.
Complete Steam line replacement Plan: 4th Qtr FY 2002	Complete Steam line replacement for Propulsion Test Area at WSTF.

Improve NASA test capabilities and achieve cost savings by implementation of planned facility readiness/closure plans

Initiate Commercial Test Operations on B-1 Test Stand Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	Complete integration of commercial operations on test stand B-1 at SSC. B-1 test stand successfully transitioned to Boeing in 2nd Qtr FY 00; RS68 engine test operations now underway.
Activate cells 2 and 3 of E-1 Test Facility at SSC Plan: 4th Qtr FY 2000 Revised: 4th Qtr FY 2001	Cell 3 activation completed 1st Qtr FY 2001; now supporting IPD LOX turbopump testing. Cell 2 activation approximately 90% complete;
Mothball test stand 4670 at MSFC Plan: 3rd Qtr FY 2000 Actual: 3rd Qtr FY 2000	Mothball test stand 4670 at Marshall Space Flight Center. TS4670 remains in inactive status pending final determination of 2nd Generation RLV testing requirements.
Initiate Commercial Development/test operations on H-1 test facility Plan: 3rd Qtr FY 2001	Turn over H-1 test facility to commercial development/test customer in support of Space Based Laser Program (SSC)

Enhance test diagnostics capabilities and increase operational efficiencies through implementation of new test technologies

Development of H2 Leak Detection System Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Develop improved H2 Leak Detection System for A/B test stand at Stennis Space Center. Fiber optics detection system design completed in FY 00; prototype hardware testing currently underway
Development of plume diagnostics Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Complete development of plume diagnostics research activities to detect metals in exhaust plumes. Developed real-time video capability for plume observations; new plume video image analysis techniques using visible or spectrally filtered video data; and continued development of atomic absorption technique for engine health monitoring;
Modular test hardware Plan: 4thQtr FY 2000 Revised: Under review	Initiate development of modular test hardware prototype at Stennis Space Center. Project postponed due to funding priorities and conflicts with test support activities
Advanced data acquisition and controls development laboratory Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Complete advanced data acquisition and controls development laboratory at Stennis Space Center. Initial installation of laboratory equipment completed in FY 00; system operations underway
Provide analysis support for testing at B-1 Test Stand Plan: 2nd Qtr FY 2001	Initiate emissions spectroscopy analysis of RS68 engine exhaust plume at B-1 test stand at SSC.
Install additional systems at E Complex at SSC Plan: 4th Qtr FY 2001	Field-test & install wireless miniature accelerometer and optic strain measurement systems at E Complex at SSC
Validate field prediction models Plan: 3rd Qtr FY 2002	Validate acoustic field prediction model for E Complex test cells at SSC
Install advanced test sensors Plan: 3rd Qtr FY 2002	Install advanced test sensors (e.g. accelerometers, flow meters, etc.) in E complex test cells at SSC.

Validate high pressure propellant flow models Plan: 4th Qtr FY 2002	Achieve highly accurate characterization of ultra high-pressure cryogenic propellant flows

Improve coordination/management of propulsion testing between NASA and DoD via efforts by the Rocket Propulsion Test Management Board (RPTMB)

Improve Scheduling/ integration tools and processes Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Develop improved scheduling/integration tools and processes. Task accomplished; integrated test utilization planning for NASA and DoD test facilities now operational
Conduct NASA/DoD cross-agency test assignments Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Achieve six NASA/DoD cross-agency test assignments. Accomplished five NASA/DoD test assignments in FY 2000 -
Establish integration and assignment process in conjunction with DoD Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Establish test integration and assignment process in conjunction with DoD. Software tools/processes established; ongoing test assignment activities conducted via RPTMB and NRPTA
Increase the number of Air Force test personnel Plan: 4th Qtr FY 2000 Actual: 4th Qtr FY 2000	Increase the number of Air Force test personnel at SSC from 1 to 3. Transitioned 1 USAF civil servant to NASA/SSC
Establish test equipment database Plan: 4th Qtr FY 2001	Establish detailed test equipment database to support future development of improved scheduling/integration tools

ACCOMPLISHMENTS AND PLANS

Over the last three years, decisions made and actions taken by NASA's Rocket Propulsion Test Management Board (RPTMB) has resulted in an estimated total savings of approximately $52 million, while the National Rocket Propulsion Test Alliance (NRPTA) has contributed another $2 million. To date, the RPTMB has made 23 propulsion test assignments within NASA, across other agencies, and to industry facilities where it was in the best interest of NASA.

During FY 2001, the RPTMB orchestrated test assignments in response to the agency's NASA Research Announcement (NRA8-30) for the Space Launch Initiative. This activity encompassed over 50 test projects, including backup options. Efforts of the NRPTA assisted in the collaboration of NASA and DoD on the RBCC program by identifying existing facility options, developing test assignments and determining appropriate facility investments. Further collaboration with DoD and commercial test customers at SSC has also resulted in the planned turnover of the H-1 test facility to Lockheed Martin for development of a facility to support the DoD's Space Based Laser program.

During FY 2002, the agency will continue to implement critical facility upgrades to ensure existing test assets are truly "world-class", thus providing flexible and robust testing capabilities operated by a highly experienced and trained cadre of test personnel. The RPTMB will continue to make test assignments that optimize utilization of existing test facilities across the agency and achieve further cost savings. Efforts will also continue in the upcoming fiscal year to execute planned facility closures and activate test facilities currently being modified in preparation for planned testing in FY 2002 and beyond. Additional investments in new test technologies will continue to enhance our ability to monitor the status of hardware during testing and increase operational safety. Investments will also continue to be made in the development of improved scheduling tools, test technology, and modularization of test support hardware to reduce turnaround times, improve test management capabilities and improve overall operational efficiencies.

BASIS OF FY 2002 FUNDING REQUIREMENT

OSF CONTRIBUTION TO ACADEMIC PROGRAMS

	FY 2000	FY 2001	FY 2002*
	(Thousands of Dollars)		
OSF Contribution to Academic Programs	[3,100]	8,000	
Education Programs.		[2,500]	
Minority University Research and Education Programs		[5,500]	

* In FY 2002, OSF funding for academic programs is transferred to Academic Programs in SAT as an agency-wide consolidation of funding in academic programs. Detailed FY 2002 information can be found in the *Academic Programs* section.

PROGRAM GOALS

The goal of the Office of Space Flight (OSF) Contribution to Academic Programs is to provide additional funding to support NASA direction for academic programs as set forth in the NASA Strategic Plan as one of the Agency's five contribution to the Nation's science and technology goals and priorities.

STRATEGY FOR ACHIEVING GOALS

In carrying out its Education Program, NASA is particularly cognizant of the powerful attraction the Human Exploration and Development of Space (HEDS) mission holds for students and educators. The unique character of the Human Exploration and Development of Space (HEDS) Strategic Enterprise's exploration, scientific, and technical activities has the ability to captivate the imagination and excitement of students, teachers, and faculty, and channel this into an investment which support NASA's Education Program.

In fulfilling its role to support excellence in education as set forth in the NASA Strategic Plan, the NASA Education Program brings students and educators into its missions and its research as participants and partners. NASA provides the opportunity for educators and students to experience first hand involvement with the Human Exploration and Development of Space (HEDS) Enterprise scientists and engineers, facilities, and research and development activities. Examples of such opportunities include the Learning Technologies Program, a new Undergraduate Internship Program, and the Graduate Student Researchers Program. The participants benefit from the opportunity to become involved in research and development endeavors, gain an understanding of the breadth of HEDS activities, and return to the classroom with enhanced knowledge and skills to share with the entire education community. Detail as to how this funding is utilized is located under the NASA Education portion of the budget.

The Human Exploration and Development of Space (HEDS) Strategic Enterprise investments in higher education institutions include Federally mandated outreach to the Nation's Historically Black Colleges and Universities (HBCUs) and Other Minority

Universities (OMUs), including Hispanic-Serving Institution and Tribal Colleges and Universities. This outreach is achieved through a comprehensive and complementary array of strategies developed in collaboration with the Office of Equal Opportunity Programs. These strategies are designed to create a broad-based, competitive aerospace research capability within Minority Institutions (MI's). This capability fosters new aerospace science and technology concepts by integrating HEDS Enterprise-related cutting-edge science and technology concepts, practices, and teaching strategies into MI's academic, scientific and technology infrastructure. As result, increasing the production of more competitive trained U.S. students underrepresented in NASA-related fields who, because of their research training and exposure to cutting-edge technologies, are better prepared to enter graduate programs or the workplace. Other initiatives are focused on enhancing diversity in the HEDS Strategic Enterprise's programs and activities. This includes exposing faculty and students from HBCUs and OMUs, and students from under-served schools, with significant enrollments of minority students, to the Enterprise's research efforts and outcomes, educational programs, and activities. To support the accomplishment of the Enterprise's mission, these programs are implemented through NASA Centers and JPL. The Centers and JPL support the MUREP through use of their unique facilities, program management and grant administration, and commitment of their personnel to provide technical assistance and assist in other facets of program implementation. Extensive detail as to how this funding is utilized is located under the MUREP portion of the budget.

SCHEDULE AND OUTPUTS

Extensive detail as to how this funding is utilized is located under the Academic Programs portion of the budget.

ACCOMPLISHMENTS AND PLANS

Beginning in FY 2002, the funding for the OSF Contribution to Academic Programs was transferred to the Academic Programs portion of the budget. Details on FY 2001 and FY 2002 activity can be found in that section.

BASIS OF FY 2002 FUNDING REQUIREMENT

TECHNOLOGY AND COMMERCIALIZATION

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
HEDS Technology and Commercialization.........................	--	19,956	19,000

PROGRAM GOALS

The goals of the Human Exploration and Development of Space (HEDS) Technology/Commercialization Initiative (HTCI) are four-fold. First, the HTCI will support HEDS analysis and planning for safe, affordable and effective future programs and projects that advance science and discovery, human exploration, and commercial development of space. Second, the Initiative will pursue research, development, and validation of breakthrough technologies and highly innovative systems concepts that open up new and potentially revolutionary system-, infrastructure- and architecture- level options for HEDS. Third, the HTCI will pursue technologies, systems and infrastructures that enable synergistic advancement of science-driven integrated human-robotic space exploration, as well as the commercial development of space. Finally, the Initiative will improve the affordability and the effectiveness with which HEDS will be able to achieve it's strategic objectives in the future by creating strong partnerships within NASA, with US industry and universities, and with international partners. By achieving these goals, the HEDS Technology/Commercialization Initiative will support better informed decisions by policy-makers concerning a) further research and technology development investments, and b) prospective future HEDS exploration initiatives and related capabilities and infrastructures. It will also make high-leverage, high-risk incremental progress toward innovative systems concepts and breakthrough technologies that could support market-driven, private sector decisions concerning commercial development of space.

STRATEGY FOR ACHIEVING GOALS

The strategic approach to accomplish the program goals of the HTCI involves three types of activities. First, HTCI will conduct systems analysis and advanced concept studies. These activities will include the formulation and refinement of new approaches (e.g., architectures, technologies, etc.) and the identification/refinement of advanced systems concepts in order to dramatically increase safety while reducing mission risk and cost for future prospective HEDS programs. Second, the Initiative will undertake HEDS-enabling advanced research and technology (HART) projects. These will be competitively selected (with a goal of 50% cost share from Industry, where appropriate), and will emphasize increases in safety, reduced risks and costs, and enabling new opportunities. Wherever possible, HART Projects will leverage other resources (including investments within NASA, other US government, industry, academia, internationally, etc.). Finally, the HTCI will conduct flight demonstration projects (including small missions, if funding permits). These flight projects will involve "new millennium-type" experiments for small robotic missions, on the International Space Station, or other carriers. This area will include flight projects that will be competitively selected (with a goal of 50% cost share from Industry, where appropriate).

SCHEDULE AND OUTPUTS

Systems Analysis and Advanced Concepts Studies - Activities supporting System Analysis and Advanced Concepts Studies will be integrated with the NASA Research Announcements (NRAs) supporting HEDS-enabling Advanced Research and Technology (HART) projects, as summarized below.

HEDS-enabling Advanced Research and Technology (HART) Projects

'01HEDS-enabling Research and Technology (HART) NASA Research Announcement Plan: 1st Qtr FY 2001	Initial solicitation of HEDS systems studies and HART technology projects; coordinated with planning for later flight demonstration projects/options.
'01HEDS-enabling Research and Technology (HART) NRA Project Announcements Plan: 3rd Qtr FY 2001	Announcement of awards from initial HART NRA.
'02HEDS-enabling Research and Technology (HART) NASA Competitive Solicitation Plan: 1st Qtr FY 2002	Second solicitation of HEDS systems studies and HART technology projects; coordinated with planning for later flight demonstration projects/options.
'02HEDS-enabling Research and Technology (HART) Competitive Solicitation Announcements Plan: 3rd Qtr FY 2002	Announcement of awards from second HART Competitive Solicitation.

Flight Demonstration Projects

'01HEDS Technology/ Commercialization Initiative NASA Research Announcement for Flight Demonstration Projects Plan: 4th Qtr FY 2001	Initial solicitation of HEDS flight demonstration projects, focusing on demonstration project definition studies; coordinated with HCTI studies and HART technology projects.

‘02HEDS Technology/ Commercialization Initiative Competitive Solicitation for Flight Demonstration Projects Plan: 1st Qtr FY 2002	Second solicitation of HEDS flight demonstration projects, focusing on demonstration project definition studies; coordinated with HCTI studies and HART technology projects.
‘01HEDS Technology/ Commercialization Initiative Competitive Solicitation for Flight Demonstration Project Definition Study Announcement Plan: 2nd Qtr FY 2002 Revised: 1st Qtr FY 2002	Second solicitation of HEDS flight demonstration projects, focusing on demonstration project definition studies; coordinated with HCTI studies and HART technology projects.

ACCOMPLISHMENTS AND PLANS

During FY 2001 the Office of Space Flight (OSF) Advanced Programs Office (APO) implemented the first year of the HEDS Technology/Commercialization Initiative (HTCI), including competitively selected activities and specific in-house activities. Preliminary validation of technologies at the component level is underway, as well as planning for potential future investment options. Flight Demonstration Project options will be defined, as appropriate.

During FY 2002, the APO will continue the implementation of HTCI projects that are competitively selected in FY2001, as well as initiating, as resources permit, a second competitive solicitation for additional projects. NASA will also continue the process of strategic road map refinement and in-house studies, research and technology development, and flight experiment definition.

BASIS OF FY 2002 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Engineering and technical base	[85,200]	73,338	75,200

Note - FY 2000 is for comparison purposes only. See Payload Utilization and Operations section for more information.

PROGRAM GOALS

The focus of the Engineering and Technical Base (ETB) is to support the institutional capability in the operation of space flight laboratories, technical facilities, and testbeds; to conduct independent safety, and reliability assessments; and to stimulate science and technical competence in the United States. ETB activities are carried out at the Johnson Space Center (JSC) including White Sands Test Facility (WSTF), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), and Stennis Space Center (SSC). ETB funds are used to: maintain the Centers' technical competence and ability to perform research; analysis and testing tasks; to solve present problems; and to reduce costs in developing programs, technologies, and materials. Efforts include system and mission analysis, integrated HSF Research and Technology (R&T) requirements definition and integration, modest R&T investments in an EVA technology demonstration project and investments in R&T required supporting the integrated Office of Space Science/HEDS robotic efforts.

STRATEGY FOR ACHIEVING GOALS

The complex and technically challenging programs managed by the Office of Space Flight (OSF), now and in the future, are most effectively carried out by sustaining a NASA "core" institutional technical base. It is vital to preserve essential competency and excellence. Since FY 1994, the OSF centers have consolidated activities and have identified ways to economize the resources committed to ETB while maintaining ETB's benefits to the nation's human space flight program. Over the next few years, this consolidation will continue to generate savings through improved information resources management and contract streamlining. A prioritized core capability will include multi-program labs and test facilities, associated systems, equipment, and a full range of skills capable of meeting research, testing and simulation demands.

As the ETB budget remains at steady state level, several activities will continue to refine current business practices. Mandatory equipment repair and replacement will be reassessed. Software applications for multi-program analytical tools will be implemented. The strategy to better manage the NASA investment in information processing resources includes aggressive actions to integrate and consolidate more ADP operations. ETB will ensure synergism among major NASA engineering programs. A key challenge of the ETB strategy will be to provide a core capability for future human space flight endeavors with fewer resources. Adoption of new innovative processes to meet critical ETB core requirements and streamlining or eliminating non-critical capabilities will enable future savings.

In FY 2001, funding for Engineering and Technical Base was moved from the Payload Utilization and Operations budget line item to a new budget line item, Investments and Support.

SCHEDULE AND OUTPUTS

Laboratories & facilities supported (KSC)	Maintains 11 science and engineering laboratories in support of 6 agency programs
Laboratories & facilities supported (JSC)	Maintains 156 science and engineering laboratories in support of 52 agency programs
Laboratories & facilities supported (MSFC)	Maintains 123 science and engineering laboratories and facilities in support of 42 agency programs
Laboratories & facilities supported (SSC)	Maintains 3 science and engineering laboratories in support of 2 agency programs
NASA Minority University Research and Education Program at JSC, KSC, MSFC & SSC	Award education and research grants

ACCOMPLISHMENTS AND PLANS

FY 2000 Accomplishments can be found in the *Payload and Utilization Operations* section.

In FY 2001 the ETB budget will continue to provide science and engineering lab support to human space flight programs, streamlined technical operations, and additional ADP consolidation activities. This will require that all Centers continue to assess their range of workforce skills, analytical tools and facilities dedicated to ensure their ability to provide space flight institutional engineering support for future human space flight programs and the existing customer base. Center assessments will focus on maintaining core support for design, development, test and evaluations, independent assessments, simulation, operations support, anomaly resolution, and systems engineering activities.

In FY 2001, a new budget line item was established for Rocket Propulsion Testing by transferring the portion of ETB budget supporting propulsion testing.

In FY 2001 MSFC will maintain ETB's institutional base requirements funding; award education and research grants to Historically Black Colleges and Universities (HBCU) to promote science and technology; maintain highly skilled Safety and Mission Assurance contractor workforce to conduct assessment of conformance to reliability and quality standards; maintain technical core capability to provide in-depth technical support for research, design, development, mission operations, and evaluation; and ETB funding for Propulsion Testing will transfer from MSFC to SSC.

In FY 2001, JSC's efforts will continue to focus on maintaining the multi-program use science and engineering laboratories and facilities operational readiness. This effort will include performing scheduled facility infrastructure sustaining maintenance, maintaining analytical tools readiness, and performing the necessary repairs, modifications, and replacements to the facilities infrastructure to accommodate the changes needed to support program commitments. FY2001 contains many critical programmatic milestones that will require extensive use of our laboratories and facilities. NASA will continue to need to perform critical studies, test, and analyses for many activities. These include: monitoring human life support and crew health as crews continue to inhabit ISS, ensuring the Shuttle can safely operate and transport Station hardware and astronaut personnel, and ensuring smooth and safe operations of personnel and equipment during the Station assembly EVAs. ETB will also keep the laboratories and facilities operational to perform exploration and development studies.

In FY 2001, KSC Materials Science Laboratory will continue providing analysis and test support to Shuttle, Space Station, Reusable Launch Vehicles, Payloads and Life Sciences programs. In the area of technology development, the KSC Materials Science Laboratory will establish Electrostatic Discharge and Corrosion Engineering Testbeds.

In FY 2002, JSC's efforts will continue to focus on maintaining the multi-program use science and engineering laboratories and facilities operational readiness. NASA will continue to perform critical studies, test, and analyses for many activities. These include: monitoring human life support and crew health as crews continue to inhabit ISS, ensuring the Shuttle can safely operate and transport Station hardware and astronaut personnel, and ensuring smooth and safe operations of personnel and equipment during the Station assembly EVAs. ETB will also keep the laboratories and facilities operational to perform exploration and development studies.

In FY 2002, KSC Materials Science Laboratory will continue providing analysis and test support to Shuttle, Space Station, Reusable Launch Vehicles, Payloads and Biological and Physical Research programs. In the area of technology development, the KSC Materials Science Laboratory will continue Electrostatic Discharge and Corrosion Engineering Testbeds.

In FY2002, MSFC ETB activities will include test area support to MSFC programs and projects that include 2nd Gen and in-house research projects; engineering, science and technical services for core capability tool development and maintenance support to Shuttle, 2nd Gen RLV, and the Propulsion Research Center; and CAD/CAM applications and hardware support to Shuttle, Station, Advanced Space Transportation, Science and in-house projects.

BASIS OF FY 2002 FUNDING REQUIREMENT

HEDS INSTITUTIONAL SUPPORT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Institutional Support to HEDS Enterprise.......... ..	[1,027,000]	[1,143,300]	1,181,500
Research and Program Management	[947,600]	[1,001,500]	1,083,088
Personnel and Related Costs............. ..	[701,700]	[765,500]	831,521
Travel	[22,400]	[25,700]	25,159
Research Operations Support............. .	[223,500]	[210,300]	226,408
Construction of Facilities	[79,400]	[141,800]	98,412
Full-Time Equivalent (FTE) Workyears	**[7,416]**	**[7,779]**	**8,092**

Note - FY 2000 and FY 2001 data in this section are for comparison purposes only. See *Mission Support* sections for more details.

PROGRAM GOALS

The two primary goals of this budget segment are to:

1.) Acquire and maintain a civil service workforce, that reflects the cultural diversity of the Nation and, along with the infrastructure, is sized and skilled consistent with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the Human Exploration and Development of Space (HEDS) Enterprise.

2.) Ensure that the facilities critical to achieving the HEDS Enterprise are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

Research and Program Management (R&PM)

R&PM provides the salaries, other personnel and related costs, travel and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 79% of the requested funding. Administrative and other support is approximately 19% of the requests. The remaining 2% of the request are required to fund travel necessary to manage NASA and its programs.

Construction of Facilities (CoF)

This budget line item provides for discrete projects required for components of the basic infrastructure and institutional facilities and almost all are for capital repair. NASA facilities are critical for the HEDS Enterprise, to sustaining the future of aeronautics and advanced space transportation, which both support critical national capabilities that are used not only for NASA, but for military and private industry users as well. NASA has conducted a thorough review of its facilities infrastructure finding that the deteriorating plant condition warrants an increased repair and renovation rate to avoid safety hazards to personnel, facilities, and mission; and that some dilapidated facilities need to be replaced. Investment in facility revitalization is needed to maintain a facility infrastructure that is safe and capable of supporting NASA's missions.

SCHEDULE AND OUTPUTS

Detailed cost estimates for HSF R&PM are shown as part of the total agency R&PM budget (see R&PM narratives) to provide a complete picture of NASA's budget requirements for personnel and administrative support. Similarly, the descriptions and cost estimates are shown as part of the Construction of Facilities program (see Construction of Facilities narratives) to provide a complete picture of NASA's budget requirement for facilities. Extensive detail as to how this funding is utilized by HSF is located under the Two-Appropriation/Mission Support portion of the budget.

ROLES AND MISSIONS

The detail provided here is for the support of HEDS Enterprise programs at the following institutions - Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, Stennis Space Center, Ames Research Center, Dryden Flight Research Center, Glenn Research Center, Langley Research Center, Jet Propulsion Laboratory, and Goddard Space Flight Center.

Johnson Space Center (JSC)

The Human Exploration and Development of Space Enterprise funds approximately 93% of JSC's Institution cost in FY 2002.

Institutional support funding at the Johnson Space Center (JSC) supports personnel carrying out the lead center management responsibility for the International Space Station program. In addition, specific JSC technical responsibilities include development of a set of facilities and systems to conduct the operations of the Space Station including on-orbit control of the Space Station. JSC also provides institutional personnel as well as engineering and testbed support to the Space Station program. This includes test capabilities, the provision of Government Furnished Equipment (GFE), and engineering analysis support for the work of the prime contractor, its major subcontractors, and NASA system engineering and integration efforts.

JSC also has lead center management responsibility for the Space Shuttle. In addition, JSC personnel will provide development, integration, and operations support for the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and other ground facilities needed for Space Shuttle Operations. JSC workers will provide Space Shuttle operational flight program management including system integration, crew equipment modification and processing, crew training, flight mission planning and operations, and procurement of Orbiter hardware.

In the Payload and ELV support program, JSC personnel provide support to payload operations and support equipment.

JSC will also conduct concept studies and development on flight systems and options for human transportation. JSC provides support to the engineering and technical and technology program support.

Space Operations Management Office (SOMO) personnel at JSC manage the telecommunication, data processing, mission operation, and mission planning services needed to ensure that the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. SOMO also provides the administration and management of the Consolidated Space Operations Contract (CSOC).

Kennedy Space Center (KSC)

The Human Exploration and Development of Space Enterprise funds approximately 94% of KSC's Institution cost in FY 2002.

The Kennedy Space Center (KSC) is a supporting center for the Space Station Program. KSC personnel have developed a set of facilities, systems, and capabilities to conduct the operations of the Space Station. KSC develops launch site operations capabilities for conducting pre-launch and post-landing ground operations including integrated testing, interface verification, servicing, launch activities, and experiment-to rack physical integration. The KSC workforce provides launch site logistics support, resupply and customer utilization. KSC serves as the primary agent for management and integration of ground processes for all U.S. launched International Space Station (ISS) elements from manufacture and assembly through verification and launch. KSC develops and maintains ISS flight systems expertise to support the ISS on-orbit mission and retains technical and operational experience within NASA and KSC for ground processing and verification of space flight hardware.

KSC workers will also provide Space Shuttle launch preparation, including orbiter processing, Ground Support Equipment (GSE) logistics; operation and maintenance of GSE; and launch and landing operations.

KSC is the Lead Center for the Payload Carriers and Support Program. KSC personnel provide technical expertise, facilities and capabilities to perform payload buildup, test and checkout, integration and servicing of multiple payloads. They also support development, operation, logistics and maintenance of Ground Support Equipment; transportation of payloads and supporting equipment to the Space Shuttle; and integration and installation of the payloads into the Space Shuttle. KSC workers develop, activate, operate and maintain the Payload Carrier facility system, GSE, and processes to enable efficient launch site processing of carriers and payloads.

KSC personnel will provide government insight/oversight of all launch vehicle and payload processing and checkout activities for all NASA contracted expendable launch vehicle and upper stage launch services both at KSC and the Vandenburg Air Force Base.

Marshall Space Flight Center (MSFC)

The Human Exploration and Development of Space Enterprise funds approximately 61% of MSFC's Institution cost in FY 2002.

Marshall Space Flight Center (MSFC) will provide engineering support to the ISS program including engineering analysis in support of the International Space Station (ISS) system engineering and integration effort. The Center also has oversight responsibility for the development of the Nodes 1 & 2, Multi Purpose Logistics Module and Interim Control Module. MSFC personnel carry out design integration of cargo elements for flight on the MSFC provided unpressurized logistics carrier to support ISS mission build and logistics supply flights. MSFC also has responsibility for developing payload utilization capabilities and planning and executing payload integration and operations activities. This includes the development and operation of the EXPRESS Rack payload carrier, the Payload Operations Integration Center, ISS Payload Data Services System and the ISS Payload Planning System. MSFC's Lead Center Microgravity Research responsibilities include managing the development of major facilities to be permanently housed on the ISS.

The Institutional Support in the Space Shuttle Projects Office (SSPO) at MSFC is responsible for executing the Space Shuttle Program role assigned to the Center. These responsibilities include activities associated with the Space Shuttle Main Engine (SSME), External Tank (ET), Solid Rocket Booster (SRB), and Reusable Solid Rocket Motor (RSRM). The SSPO is responsible for these propulsion hardware elements and associated systems, test and flight operations, and facilities.

MSFC manages and maintains the NASA Integrated Services Network (NISN) - NISN services provide communications hardware, software, and transmission medium that inter-connects NASA Headquarters, installations, universities, and major contractor locations for the transfer of data, voice, and video.

Stennis Space Center (SSC)

The Human Exploration and Development of Space Enterprise funds approximately 58% of SSC's Institution cost in FY 2002.

The Stennis Space Center will provide, maintain and manage the facilities and the related capabilities required for the continued development and acceptance testing of the Space Shuttle Main Engines.

As the Lead Center for Propulsion Testing, SSC will operate, maintain, and manage a propulsion test capability that includes test facilities at JSC/WSTF, MSFC and GRC/Plum Brook and related systems for development, certification, and acceptance of rocket propulsion systems and components. SSC will also maintain and support the Center's technical core laboratory and operations to enable SSC to conduct advanced propulsion test technology research and development for government and commercial propulsion programs.

Ames Research Center (ARC)

The Human Exploration and Development of Space Enterprise funds approximately 8% of ARC's Institution cost in FY 2002. Ames Research Center has the agency lead role in Gravitational Biology and Ecology programs. These synergistic programs examine the adaptation of life forms to reduced gravity.

Dryden Flight Research Center (DFRC)

The Human Exploration and Development of Space Enterprise funds approximately 22% of DFRC's Institution cost in FY 2002. DFRC conducts technology development and flight test of the X-38 vehicle. They also provide operational and technical support for the conduct of Space Shuttle missions, including on-orbit tracking and communications, landing support of crew and science requirements.

Glenn Research Center (GRC)

The Human Exploration and Development of Space Enterprise funds approximately 23% of GRC's Institution cost in FY 2002. GRC support to the space station program includes technical and management support in the areas of power and on-board propulsion components and system, engineering and analysis, technical expertise, and testing for components and systems. This includes use of facilities and testbeds and construction of flight hardware as required. GRC also develops and demonstrates communications and network technologies in relevant environments to enhance the performance of existing mission services or enable new services. These people identify and infuse new capabilities at higher frequencies (Ka-band and above) into the next generation of spacecraft and communications satellites, to enable seamless interoperability between NASA assets and commercial space and ground networks. The Center's personnel also ensure timely and high-quality availability of radio frequency spectrum to enable the realization of NASA goals.

Langley Research Center (LaRC)

The Human Exploration and Development of Space Enterprise funds approximately 3% of LaRC's Institution cost in FY 2002. LaRC supports the HEDS Enterprise through systems analyses of potential Space Station evolution as well as future human exploration missions in space.

Jet Propulsion Laboratory (JPL)

The Human Exploration and Development of Space Enterprise funds approximately 35% of JPL's Institution cost in FY 2002 in the areas of other than direct Research Operations Support and Construction of Facilities funding. JPL manages NASA's Deep Space Network (DSN) communication complexes for the Johnson Space Center, the Space Operations Lead Center, a critical program element of Space Operations. DSN communications complexes are strategically placed on three continents - in California's Mojave

Desert, in Australia, and in Spain. The DSN provides the two-way communications link that guides and controls spacecraft and brings back images and other scientific data. The DSN, the largest and most sensitive scientific telecommunications system in the world, also performs radio and radar astronomy observations for the exploration of the solar system and the universe.

Goddard Space Flight Center (GSFC)

The Human Exploration and Development of Space Enterprise funds approximately 14% of GSFC's Institution cost in FY 2002.

GSFC manages flights of the Hitchhiker, a reusable carrier system that provides increased flight opportunities with reduced lead-time while maximizing Space Shuttle load factors and minimizing spaceflight costs. GSFC personnel also manage and coordinate the Agency's Get Away Special (GAS) program.

Research and technology activities at GSFC involve the investigation and development of advanced systems and techniques for spacecraft communications and tracking, command and control, and data acquisition and processing. The primary objectives are to apply technology and develop advanced capabilities to meet the tracking and data processing requirements of new missions and to improve the cost effectiveness and reliability of flight mission support.

Although the Johnson Space Center is designated as the Space Operations Lead Center, GSFC personnel manage a number of critical program elements, including: operation of the Tracking and Data Relay Satellite System (TDRSS); the development of the replenishment TDRSS spacecraft; mission control, data processing, and orbit/attitude computation support; operating the Space Tracking and Data Network (STDN), the NASA Communications (NASCOM) Network, and the Aeronautics, Balloons and Sounding Rocket Program. The NASCOM Network links the stations of the Deep Space Network (DSN), STDN, TDRSS, and other tracking and data acquisition elements with control centers and data processing and computation centers.

Headquarters (HQ)

The Human Exploration and Development of Space Enterprise funds approximately 35% of HQ's Institution cost in FY 2002. The Enterprise's Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTE's across the agency. A more complete description can be found in the Mission Support/Two Appropriation budget section.

HUMAN SPACE FLIGHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **SPACE OPERATIONS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Operations	[326,500]	(349,738)	258,900	HSF 6-4
Mission and Data Service Upgrades	[97,600]	(82,811)	62,400	HSF 6-10
Tracking and Data Relay Satellite System Replenishment Project	[31,700]	(50,879)	125,500	HSF 6-17
Technology	[40,200]	(38,316)	35,400	HSF 6-19
*[Budget Offsetting Reimbursements [non-add]]	[[43,000]]	[[43,000]]	[[43,000]]	
Total	[496,000]	[521,743]	482,200	

Distribution of Program Amount by Installation

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET
Johnson Space Center	[223,900]	(225,593)	139,000
Kennedy Space Center	[15,100]	(37,111)	69,000
Marshall Space Flight Center	[4,800]	(8,800)	9,000
Dryden Space Flight Center	[12,800]	(12,743)	13,000
Glenn Research Center	[10,100]	(8,990)	7,300
Goddard Space Flight Center	[88,900]	(92,071)	109,300
Jet Propulsion Laboratory	[134,400]	(113,016)	129,400
Headquarters	[6,000]	(23,419)	6,200
Total	[496,000]	[521,743]	482,200

Note - FY 2000 data in this section are for comparison purposes only. See Mission Communication Services and Space Communications Services for more details on FY 2000 activity.

* –Budget offsetting reimbursements are that portion of total program reimbursable revenue that partially defray the fixed and variable costs of operating a NASA multi-mission facility as a service to a variety of NASA and non-NASA users.

PROGRAM GOALS

The program goal is to provide reliable, quality and cost-effective space operations services that enable Enterprise mission execution. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The Space Operations Management Office (SOMO), located at the Johnson Space Center in Houston, manages the program to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. In line with the National Space Policy, the SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participate with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for operational communications and associated information handling services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests.

STRATEGY FOR ACHIEVING PROGRAM GOALS

The Space Operations program provides command, tracking, and telemetry data services between the ground facilities and flight mission vehicles. This includes all the interconnecting telecommunications services to link tracking and data acquisition network facilities, mission control facilities, data capture and processing facilities, industry and university research and laboratory facilities, and the investigating scientists. The program provides scheduling, network management and engineering, pre-flight test and verification, flight system maneuver planning and analysis. The program provides integrated solutions to operational communications and information management needs common to all NASA strategic enterprises.

The Space Operations program provides the necessary research and development to adapt emerging technologies to NASA communications and operational requirements. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the evaluation and coordination of data standards and communication frequencies to be used in the future.

The Space Operations program provides spectrum management support for all missions across the NASA strategic enterprises. Future spectrum and orbit requirements are identified and integrated into National and international regulatory activities to assure near-term and far-term Agency requirements are met.

Many science and exploration goals are achieved through inter-agency or international cooperation. Services from NASA's Space Operations assets are provided through collaborative agreements with other U.S. Government agencies, commercial space enterprises, academia, and international cooperative programs. Consistent with the National Space Policy, NASA procures commercially available goods and services to the fullest extent feasible, NASA develops selected technologies which leverage commercial investments and enable the use of existing and emerging commercial telecommunications services to meet NASA's Space Operations needs. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

The Consolidated Space Operations Contract (CSOC) was successfully implemented on January 1, 1999, under the direction of the Space Operations Management Office and Lockheed Martin Space Operations Company as the Prime Contractor. CSOC provides end-to-end space operations mission and data services to both NASA and non-NASA customers. CSOC is a $3.44B contract with a Basic Period of Performance from January 1999 through December 2003 and an option period though December 2008. CSOC is a Performance Based Cost Plus Award Fee (CPAF) contract. A total of nine contracts have been consolidated to date, and seven further contracts are to be consolidated in FY 2001 and FY 2002. CSOC reflects a significant change in NASA philosophy as accountability and day-to-day direction for providing space operations services shifts from NASA to the CSOC contractor.

Although FY 2001 activity is discussed in this section, the funding was appropriated in the Science, Aeronautics and Technology (SAT) appropriation. Budget data for that year is provided both here and in the Space Operations section in the SAT appropriation for completeness.

BASIS OF FY 2002 FUNDING REQUIREMENT

OPERATIONS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Space Network	[2,500]	[40,619]	27,000
Deep Space Network	[81,700]	[149,870]	118,600
Ground Networks	[23,300]	[36,021]	24,500
Mission Control and Data Systems	[211,500]		
Wide Area Network	[7,500]	[97,715]	54,100
Mission Services		[8,581]	17,100
Western Aeronautical Test Range		[12,472]	13,000
Spectrum Management		[4,590]	4,300
Standards Management		[299]	300
Total	[326,500]	[349,748]	258,900

PROGRAM GOALS

Space operations functions are defined as those activities that provide "mission" and "data" services to customers to enable their utilization and exploration of space. The mission and data services goal is to provide high-quality, reliable, cost-effective operations that support planning, system engineering, design, development, and analysis to a large number of NASA missions including planetary and interplanetary missions; human space flight missions; near-Earth and Earth-orbiting missions; sub-orbital and aeronautical test flights.

STRATEGY FOR ACHIEVING GOALS

Mission services provide for the launch and early orbit implementation, maintenance, and operations of the mission control and data processing facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems. Mission service operations are conducted in the facilities provided by NASA at multiple locations both in the United States and at overseas sites. Data Services provide command, tracking, and telemetry data services between the ground facilities and flight mission vehicles. This includes all the interconnecting telecommunications services to link tracking and data acquisition network facilities, mission control facilities, data capture and processing facilities, industry and university facilities, and the investigating scientists.

Data services are also provided to non-NASA customers on a reimbursable basis. A large share of the program that provides space network ground terminal complex operations and maintenance is funded with the receipts from reimbursable services.

SCHEDULE AND OUTPUTS

	FY 2000		FY 2001		FY 2002
	Plan	Actual	Plan	Current	Plan
Deep Space Network					
Number of NASA missions	[51]	[51]	[47]	[51]	51
Number of hours of service	[84,000]	[94,000]	[81,000]	[84,000]	84,000
Ground Network					
Number of Space Shuttle launches	[8]	[6]	[9]	[7]	7
Number of NASA/Other ELV launches	[25]	[22]	[54]	[25]	25
Number of NASA Earth-Orbiting missions	[37]	[32]	[32]	[37]	37
Number of Sounding Rocket deployments	[25]	[27]	[25]	[25]	25
Number of Balloon deployments (scientific)	[26]	[26]	[26]	[26]	26
Number of hours of service (GN Orbital Tracking)	[25,200]	[24,000]	[23,000]	[25,200]	25,200
Western Aeronautical Test Range					
Number of hours mission control center	[1,450]	[2,504]	[1,875]	[1,875]	1,875
Number of hours of data services support	[24,000]	[24,000]	[27,000]	[27,000]	30,000
Mission and Control Data Services					
Number of NASA spacecraft supported by GSFC mission control facilities	[23]	[16]	[25]	[22]	23
Number of mission control hours of service (in thousands)	[67,000]	[47,000]	[62,000]	[58,000]	58,000
Number of NASA/Other missions provided flight dynamic services	[49]	[54]	[49]	[45]	46
Number of NASA/Other ELV launches supported by flight dynamic services	[22]	[20]	[22]	[20]	30
Other					
NASA Integrated Systems Network - number of locations connected	[420]	[347]	[420]	[340]	323
Number of hours of space network services in thousands	[62,000]	[78,000]	[61,000]	[61,000]	61,000

ACCOMPLISHMENTS AND PLANS

The Space Network (SN) encompasses the White Sands Complex in New Mexico, the Guam Remote Ground Terminal and the Network Control Center at GSFC to operate the constellation of Tracking and Data Relay Satellites (TDRS). The SN is required to operate 24 hours per day, 7 days per week, providing data relay services to many flight missions. In FY 2001 and FY 2002, the missions to be supported include Space Shuttle flights and their attached payloads, observatory-class spacecraft in low-Earth orbit, such as Hubble Space Telescope (HST), as well as other compatible missions such as Ocean Topography Experiments, Department of Defense customers, the Rossi X-ray Timing Explorer (RXTE), the Starlink research aircraft, Engineering Test Satellite (ETS-VII), Tropical Rainfall Measurement Mission (TRMM), Landsat-7, and the Long Duration Balloon program. The Space Network extended service (on a reimbursable basis) to the expendable launch vehicle community, including agreements with US Air Force Titan, Lockheed Martin's commercial Atlas programs, Boeing's Delta program and Sealaunch program. In FY 2001 and FY 2002, the Space Network will continue to provide services to the Space Shuttle Flights and their attached payloads as well as the construction phase of the ISS

The Deep Space Network (DSN) includes the Goldstone Deep Space Communication Complex (GDSCC) in California, the Madrid Deep Space Communications Complex (MDSCC) in Spain, and the Canberra Deep Space Communications Complex (CDSCC) in Australia. The DSN plans to provide approximately 84,000 hours of tracking support to over 50 missions during FY 2001 and FY 2002. These included NASA, NASA cooperative and reimbursable spacecraft launches. Special tracking coverage was provided in support of spacecraft emergencies and anomalies. The number of missions serviced by the DSN facilities and the requirements of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems will be phased out or converted for alternate uses. The DSN has been reconfigured with four new 34-meter antenna systems located at Goldstone, Canberra, and Madrid. These 34-meter antennae will satisfy expanded coverage requirements, and provide simultaneous coverage of deep space mission. In FY 2000, the 70-meter antenna located at Goldstone was upgraded to provide x-band capability. An 11-memer antenna system has been installed at each DSN complex to provide science support for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operations Program (VSOP) spacecraft.

The Ground Network (GN) is comprised of tracking stations in Poker Flats Research Range near Fairbanks, Alaska, Bermuda, Merritt Island (MILA), Svalbard, Norway, McMurdo Ground Station in the Antarctic, and Wallops Island. The GN provides launch support, polar orbiting spacecraft support, and sounding rocket and atmospheric balloon mission support. The GN also supports critical Space Shuttle launch, emergency communications, and landing activities. The GN provides for the implementation, maintenance, and operation of the tracking and communications facilities necessary to fulfill program goals for flight projects in the NASA mission set. Missions supported also include NASA inter-agency collaborative programs, commercial enterprises, and other national, international, and commercial enterprises on a reimbursable basis. The Space Shuttle launches were successfully supported through dedicated facilities of the MILA station and the Ponce de Leon inlet annex. The continuation of this support, further enabled by the implementation of the re-engineered STDN system elements, is expected throughout FY 2001 and FY 2002. The University of Chile is providing southern hemisphere coverage for polar orbiting missions as well as planned early launch support to Mars Odyssey during FY 2001. Wallops Flight Facility (WFF) completed the installation of the 11-meter telemetry antenna systems at the Poker Flat Research Range near Fairbanks, Alaska and at Svalbard, Norway in preparation for support of the Terra, Quickscat, and Landsat-7 missions.

The NASA Dryden Flight Research Center (DFRC) Western Aeronautical Test Range (WATR) provides communications, tracking, data acquisition, and mission control for a wide variety of aeronautic and aerospace vehicles. The WATR meets widely diverse research project requirements with tracking, telemetry, and communication systems and control room complexes. Due to the nature of the aeronautical research mission, it is essential to respond to new project requirements within days or weeks rather than months or years, and to do so safely, efficiently, and economically. To accomplish this, WATR facilities, systems, and processes are designed to support a wide range of requirements, be easily reconfigured (less than one hour for control rooms), to be shared between multiple projects, and to readily interface with specialized equipment brought in by our customers. This approach provides the needed agility to be responsive while reducing costs to individual customers by increasing utilization rates. Customers of the WATR facilities include other NASA Centers, the U.S. Army, U.S. Air Force, U.S. Navy, Federal Aviation Administration, and the aerospace industry. In addition to providing over 2500 hours of Mission Control Center support to a variety of programs, the WATR also provided on-orbit support to the MIR and ISS as well as the Space Shuttle. Two Shuttle landings have been supported in FY01 to date. Significant FY 2000 and FY 2001 activities include the build-up of a Mission Control Center and data processing system to support unique X-40A, and X-43 (Hyper-X) requirements. A work-around was developed to support classified data on a limited basis. The test range was also extended to the West Coast to support the X-43 launch over the Pacific Ocean late in FY 2001.

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOC) for the Hubble Space Telescope (HST) program; the International Solar Terrestrial Physics (ISTP) Wind, Polar, and Solar Observatory for Heliospheric Observation (SOHO); Rossi X-ray Timing Explorer (RXTE), Total Ozone Mapping Satellite-Earth Probe (EP), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Transport Region and Coronal Explorer (TRACE); and Submillimeter Wave Astronomy Satellite (SWAS) missions, and the Multi-satellite Operations Control Center (MSOCC) which supports Upper Atmosphere Research Satellite (UARS) and Earth Radiation Budget Satellite (ERBS) missions. The Advanced Composition Explorer (ACE), Tropical Rainfall Measurement Mission (TRMM), the International Monitoring Platform (IMP-8), and Land Satellite (Landsat-7) are also operated out of GSFC MOCs. Science data processing support is provided for the ISTP/Geomagnetic Tail (Geotail) mission. Microwave Anisotropy Probe (MAP), the second Medium-class Explorer (MIDEX), is scheduled to be launched in June 2001.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data (Level 0) prior to its distribution to science operations centers and to individual instrument managers and research teams. The Earth Observation System (EOS) Data and Operations System (EDOS) began supporting the EOS Terra (AM-1) mission and is preparing for the second mission of the EOS series, Aqua (PM-1) currently planned for July 2001. EDOS provides the science data processing capability and product generation and delivery for the EOS missions. In addition, the Terra mission is supported via the SN and transmits telemetry to the EDOS Ground System Interface Facility (GSIF) located at the WSC for storage and delivery to the EDOS Level Zero Processing Facility (LZPF) located at GSFC.

Flight dynamics services were provided to all NASA space flight missions that utilize NASA's Space Network and to selected elements of the Ground Network, including the Space Shuttle, Expendable Launch Vehicles, and satellite systems. Attitude software and simulator development was provided for the TRACE, ACE, and TRMM flight systems. Flight dynamics ground systems for routine support was provided for MAP and the EOS Aqua (PM-1) during FY 2001. MAP will be launched in June 2001 and two Small Explorer missions (SMEX) are expected to launch in FY 2001 and FY 2002: the High Energy Spectroscopic Imager (HESSI) is to launch in FY 2001; the Galaxy Evolution Explorer (GALEX) will launch in FY 2002. These missions emphasize reduced mission costs and accelerated launch schedules.

NASA Integrated Services Network (NISN) provides for the implementation, maintenance, and operation of the telecommunications services, control centers, switching systems, and other equipment necessary to provide an integrated approach to NASA communications requirements. NISN completed the transition of the NISN Video Teleconferencing Service to the General Services Administration's Federal Telecommunications Services (FTS) 2000 Switched Compressed Video Transmission Service (SCVTS). This video service is shared by several government agencies, provides connectivity to commercial video services such as those provided by Sprint and MCI, and is also compatible to desktop video systems. This transition standardizes NASA video teleconferencing service on the industry standard of voice activated switching, and provides greater access to non-NASA video systems. In FY 2001, NISN will continue to analyze commercial services for potential use in meeting NASA's expanding Mission Requirements. NASA will be adding services to support continued implementation of IFMP, the Consolidated Supercomputing Management Office (CoSMO), ISS Phase II, National Oceanic and Atmospheric Administration (NOAA)-K, Earth Observation System, Advanced Composition Explorer (ACE), Advanced Earth Observing Satellite (ADEOS) and TRMM.

In FY 2002, the mission services asynchronous transfer mode (ATM) infrastructure will be completed. This new infrastructure will allow for improved technology and performance in providing mission services to both human and robotic space programs. The induction of voice over Internet protocol will be introduced into the mission infrastructure allowing a low cost solution to NASA's principal investigators participating in NASA's missions. In conjunction with NASA Research and Education Network (NREN), NISN has entered into formal agreements with other Government Agencies and Organizations to pass data over their networks, both research and operations. These agreements prove to be cost-effective for the Agency in that it reduces the need to install dedicated circuits to partnering universities and principal investigators. Such agreements also assures that NASA's remote users have advance network capabilities in more timely matter. NASA's peering agreements includes Commercial Internet Service Providers, Federal & Academic Research Networks (Abilene, DREN, Esnet, Argonne National Labs, vBNS+), and International Research Networks (Canada, Japan/Korea, Singapore, Germany, England, Israel). NASA's peering agreements will continue to be improved to provide NASA greater connectivity to the university and research networks without expensive dedicated circuits to those locations. In the fourth quarter of FY 2002, NISN plans to implement web caching at the peering locations, off loading outside traffic to popular NASA web sites from the NASA internal network allowing improved throughput between NASA centers. Improvements in voice and video teleconferencing will be implemented as technology matures.

The Spectrum Management program achieved significant success in FY 2000 at the 2000 World Radiocommunications Conference held May 8 – June 2, 2000 in Istanbul, Turkey. Allocations were achieved that will protect spaceborne navigation for NASA missions, including the International Space Station and Space Shuttle, using the Global Positioning System (GPS). In addition, NASA's efforts helped to ensure that the GPS remain the preeminent navigational aid for commercial aviation and other important applications. A complete realignment of the Table of Frequency Allocations in the range 71 – 275 Ghz was accomplished that will enable enhanced spaceborne sensing of the Earth's environment. In addition, existing allocations used in support of critical NASA operations were safeguarded from intrusion by incompatible services. For FY2001, the Spectrum Management program has begun preparations for the 2003 World Radiocommunications Conference (WRC-2003). Study efforts are being conducted to prepare the technical bases for Agency proposals to WRC-2003. These efforts include enhancement of frequency allocations for spaceborne radars, protection of vital tracking and data relay capabilities and ensuring the protection of sensitive signals from deep space scientific research. The program will leverage its activities through coordination with other civil space agencies throughout the World by participation in the Space Frequency Coordination Group. The program is also helping to foster NASA's commercialization goals by working with the National regulatory agencies to solve the associated regulatory challenges. The program will continue to support NASA missions in obtaining national and international authority to operate in a protected and properly allocated manner.

BASIS OF FY 2002 FUNDING REQUIREMENT

MISSION AND DATA SERVICES UPGRADES

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Space Network	[1,700]		
Deep Space Network	[39,500]		
Ground Networks	[7,700]		
Mission Control and Data Systems	[48,700]		
Mission Services		[32,129]	28,900
Data Services		[50,682]	33,500
Total	[97,600]	(82,811)	62,400

PROGRAM GOALS

The goal of Mission and Data Services Upgrades Project is to enable the conduct of the NASA strategic enterprises by implementing required upgrades to space operations systems and services. Reliable electronic communications and mission control systems are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The Mission and Data Services Upgrades Project, one part of NASA's Space Communications program, is composed of Data Services Upgrades and Mission Services Upgrades. Data Services Upgrades are made to the Space Network, Deep Space Network, and Ground Network. Mission Services Upgrades are made to mission control and data processing systems. These areas establish, operate, and maintain NASA ground networks, mission control, and data processing systems and facilities to provide communications service to a variety of flight programs. These include deep space, Earth-orbital, research aircraft, and sub-orbital missions. Mission support service facilities that perform functions such as orbit and attitude determination, spacecraft navigation and maneuver support, mission planning and analysis and several other mission services are also upgraded as part of this project.

STRATEGY FOR ACHIEVING GOALS

Upgrade tasks are being conducted on the Space Network, the Deep Space Network, the Ground Network, and the mission control and data processing systems to enable the conduct of on going and new missions by the NASA strategic enterprises. These upgrades are implemented by the Goddard Space Flight Center, the Jet Propulsion Laboratory, and their respective industry partners.

A major upgrade effort is underway to reduce operations costs for the Space Network and Ground Network through the implementation of the Data Services Management Center at the White Sands, New Mexico. This effort involves consolidating scheduling, management, and control of operations for the Space Network and Ground Network, including relocating the Network Control Center (NCC). The NCC, currently located at the Goddard Space Flight Center in Maryland, provides the primary interface for all Space Network customer missions. The primary function of the NCC is to provide scheduling for customer mission services. In addition, the NCC generates and transmits configuration control messages to the network's ground terminals and TDRS satellites and provides fault isolation services for the network. The Mission and Data Services Upgrades Project provides comprehensive mission planning, user communications systems analysis, mission analysis, network loading analysis, and other customer services and tests to ensure network readiness and technical compatibility for in-flight communications.

In the Deep Space Network (DSN) area, JPL is working with its industry contract partners to transform the DSN and associated mission operations system architecture into a service provision system known as the Deep Space Mission System (DSMS). The DSMS will provide a customer-oriented, turnkey service system which seamlessly integrates the facilities of the DSN and the Advanced Multi-Mission Operations System (AMMOS). This system will enable more efficient provision of currently available services as well as the creation of entirely new services.

Beyond efficiency improvements to existing assets, NASA is exploring ways to enhance the amount of deep space communications capability that can be applied to servicing the growing exploration fleet. NASA efforts along these lines include international cooperation and technology upgrades to existing assets.

In the international cooperation arena, NASA, through JPL, is working with other space-faring nations to implement a standardized set of communications protocols that will allow spacecraft interoperability with U.S. and foreign ground communications assets. NASA is also working to establish the agreements necessary to utilizing such interoperability – one example under discussion is the possible application of Italy's planned 64 meter Sardinia antenna to the support of some U.S. deep space missions.

In NASA's other effort for supporting the growing exploration fleet, applying technology improvements to existing DSN communications assets, JPL is working to improve capacity through data processing and antenna feed enhancements at current radio frequencies and through the application of higher radio, and even optical, frequencies. This will enable significant leaps in the data rates available for future missions. The first major new radio frequency improvements involve the addition of Ka-band reception capability on all of the DSN's 34-meter beam wave-guide antennas. NASA is also working to develop the corresponding Ka-band transmission hardware needed for the flight elements.

The Ground Networks upgrades area, in conjunction with other NASA and commercial elements, is demonstrating and implementing automated ground station control software systems to allow for increased reliability and lower overall operating costs. The completion of the implementation of the autonomous polar ground stations in Alaska and Norway will demonstrate these new capabilities using commercial and in-house developed software systems as the primary source of this function.

Efforts to reduce the cost of operations for low-Earth orbit spacecraft will continue with the commercialization of ground based tracking systems. The goal of these efforts is to provide a low-cost ground tracking capability utilizing commercial ground tracking services in lieu of building additional government assets. This concept is being validated by the NASA/CSOC polar tracking services contracts with the Honeywell DataLYNX and Konsberg Lockheed Martin contractors in support of the EOS Program. Re-engineering efforts will be completed in early FY 2001 on the Ground Network facilities, resulting in reduced operation and maintenance costs. The UHF air-to-ground voice service at the Bermuda station remains available for Space Shuttle launch operations.

The Mission Services Upgrades area, primarily managed by the GSFC, is comprised of a diverse set of facilities, systems and services necessary to support NASA flight projects. The mission control function consists of planning scientific observations and preparing command sequences for transmission to spacecraft to control all spacecraft activities. Mission Operation Centers (MOC's) interface with flight dynamics, communications network, and science operations facilities in preparation of command sequences, perform the real-time uplink of command sequences to the spacecraft systems, and monitor the spacecraft and instrument telemetry for health, safety, and system performance. Real-time management of information from spacecraft systems is crucial for rapid determination of the condition of the spacecraft and scientific instruments and to prepare commands in response to emergencies and other unplanned events, such as targets of opportunity. The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data prior to its distribution to science operations centers and to individual instrument managers and research teams.

A major effort within the mission control and data systems is the development of more cost-effective mission operations systems to support the Explorers Program. Approximately one spacecraft per year will be launched, with potentially every other MIDEX mission operated from GSFC, dependent on successful Principal Investigator teaming arrangements. To minimize operations costs, plans for the MIDEX missions include consolidating the spacecraft operations, flight dynamics and science data processing all into a single multi-mission control center. Many of the functions will be automated using a commercial expert system product. The control center system will be used for spacecraft integration and test, thereby eliminating the need and cost of unique spacecraft manufacturers integration and test systems.

The Office of Space Science Mars Exploration Program has initiated funding beginning in FY 2001 to implement an additional 34-meter beam wave guide antenna in Spain to meet DSN mission loading requirements in FY 2003/FY 2004.

SCHEDULES AND OUTPUTS

Deep Space Network - DSN 26M Electronics Development Complete Plan: 4th Qtr FY 2001	Automate and upgrade the existing electronics in the 26M antennas to support unattended operations (i.e., no operations staff is nominally required).
Ground Network - McMurdo Ground Station Upgrades Complete Plan: 2nd Qtr FY 2001	Upgrade the existing facility (joint with the USAF) to improve operability during inclement weather and support future cooperation with the USAF.
Mission Services – PACOR Automation Complete Plan: 3rd Qtr FY 2001	Automate and upgrade existing data processing systems to reduce operations costs.
KA-Band Ground Terminal Development Complete Plan: 4th Qtr FY 2001	Implement a Ka-Band ground terminal to test and demonstrate high rate ground data acquisition at this higher frequency.
Space Network Demand Access System Complete Plan: 1st Qtr FY 2002	Implement an improved Space Network multiple access system to provide increased capacity to support new operational uses of the TDRSS.

ACCOMPLISHMENTS AND PLANS

Data Services Upgrades

The Ka-Band Ground Terminal Development activity began in FY 2000. This effort will seek to demonstrate the commercial viability of providing high rate ground data acquisition in the Ka-Band area. This activity will include participation by members from various NASA centers and commercial vendors. The successful demonstration of this capability is scheduled for late FY 2001. Capabilities to be demonstrated are far beyond what is in operation today. Success will allow NASA and its commercial partners to take advantage of the new frequency allocations for space and earth science and to alleviate issues regarding radio frequency spectrum interference that exist today.

The requested funding also provides for continuation of mission planning, customer requirements definition and documentation, mission and network operational integration, analyses, customer communications systems analyses, test coordination and conduct, and other customer support services in support of Space Shuttle and the International Space Station (ISS).

Work will continue in FY 2001 on various components of the Space Network Demand Access System (DAS). The Third Generation Beam Forming System (TGBFS) development activity was completed to augment the TDRSS multiple-access (MA) capability and to permit customers to implement new operations concepts incorporating continuous return link communications. The DAS will expand existing Multiple Access (MA) return service capabilities by allowing customers to directly obtain services from the Space Network without scheduling through the Network Control Center (NCC). The DAS will be installed at White Sands, New Mexico, and is expected to be operational and available for customer use in FY 2002.

JPL has also been working to decrease the Deep Space Network's complexity and improve equipment reliability, thereby enabling substantial DSN operations and maintenance cost savings. Efforts along these lines include improved network control, network simplification, upgrades to the 26-meter antenna subnet, and the replacement of aging electronics systems.

The Network Simplification Project (NSP) has continued on schedule. NSP consolidates or replaces all the telemetry and radiometric DSN equipment with new technology and COTS solutions that enable advanced capabilities and remote operations. The objectives include replacing failure-prone aging assemblies, reducing system interfaces, reducing manual switches, replacing old NASA-unique protocols with industry standards, and providing new deep space mission command services to eliminate labor-intensive controller functions. The final installations are planned for mid-2002 through 2003. The first-of-a-kind uplink and downlink replacement systems will be installed on the DSS-26 34-meter beam wave-guide antenna at Goldstone for operational testing during FY 2002.

Implementation continues on the telecommunications roadmap that was developed in FY 1998. The roadmap laid out a plan for using new technologies to increase the DSN's deep space communications capabilities to accommodate a growing exploration fleet while maximizing the utility of the existing DSN antennas. The first major goal of this implementation will be the addition of Ka-band reception capability on all of the DSN's 34-meter beam wave-guide antennas. An implementation plan was developed in FY 1999 that has successfully passed a preliminary definition and cost review, and has moved on to prototyping activities for certain key technologies. One of these technologies currently under test is a single microwave feed horn and associated cryogenic low-noise amplifiers that can receive both X-band (8 GHz) and Ka-band (32 GHz) simultaneously. The other significant effort undertaken as part of the telecommunications roadmap is the completion of the DSS-26 34-meter antenna at Goldstone. The electronics for this antenna are being developed and installed to make this antenna operational in FY 2002.

The 70 meter X-band Uplink task is implementing a higher power transmit capability to better communicate with spacecraft in the outer solar system. The upgrade to the antenna at Goldstone, California was completed in FY2000 The upgrade to the antenna at Canberra, Australia will be completed in FY2001. The remaining antenna at Madrid, Spain will be upgraded in FY2002. The 34-meter antenna-arraying task has been completed. This task has already demonstrated the improved performance achievable through the use of an array of multiple antennas.

The Ground Network consists of the Merritt Island Launch Area (MILA) station and the Ponce de Leon (PDL) inlet annex in support of Shuttle launch and landing activities. The potential for the long-term replacement of aging 9-meter hydraulic antennas at MILA by a commercial ground station is being studied. Infusion of technology developed in support of receiver, exciter, and ranging subsystems will be introduced in a phased manner to replace aging subsystems at MILA and Ponce de Leon. This effort will continue throughout FY 2001.

NASA is planning for the future of the McMurdo Ground Station (MGS) in Antarctica. The drivers for this station are the need to provide for predictable performance of MGS in support of Launch and Early Orbit Operations, to provide for supplemental telemetry support, and to pursue a mutually beneficial relationship with the U. S. Air Force with regard to improved service and cost sharing. Concept definition, project plans, and approval to proceed were granted in FY 1999. Upcoming plans for MGS in FY 2001 include the implementation of a Joint Operations Center (JOC) with the U. S. Air Force and subsystem upgrades in support of the EOS missions.

Mission Services Upgrades

The Mission Services Upgrades area has pursued proactive measures to consolidate functions, close marginal facilities, and reduce overall contractor workforce to reflect the Agency's goals. Examples include the automation of flight dynamics tasks and the automation of data packet processing tasks at GSFC.

Transfer of data systems technologies to flight project use occurred in the areas of software reuse, expert system monitoring and command of spacecraft functions, and packet data processing systems. Software reuse, expert systems, workstation environments, and object-oriented language applications continued. The Mission Control and Data Systems upgrades areas will continue to integrate modern technology into mission operations support systems through the use of systems like the Generic Spacecraft Analyst Assistant (GenSAA) for automation, software-based telemetry front-end processing systems and the Mission Operations Planning and Scheduling System, case-based and model-based reasoning tools, and commercial orbit planning systems.

Significant development, test, and pre-launch support associated with the MIDEX and SMEX missions are part of the Mission Control and Data Systems activity. Emphasis upon commercial products, artificial intelligence applications and advanced graphical displays will be continued in FY 2001 for application in MIDEX and future SMEX missions. Evolution of systems to a single integrated mission control, command management, flight dynamics, and first-level science processing system will continue. New flight dynamics technology development and infusion for autonomous space and/or ground spacecraft navigation and control will be major efforts.

The Mission Services Upgrades efforts will continue to focus efforts on operations automation beyond the Flight Dynamics COTS Infusion and PACOR Automation tasks. The Flight Dynamics COTS Infusion task completed in FY2000 and utilized commercial software tools to automate orbit determination functions at GSFC and reduce operations costs. The PACOR Automation task is automating data processing functions at GSFC to reduce operations costs. PACOR Automation will be completed to support the Hubble Space Telescope and Tropical Rainfall Measuring Mission (TRMM) in FY2001 and the Earth Radiation Budget Satellite (ERBS) mission in FY2002.

Mission Services Upgrades area will continue the lead in scoping and prototyping innovative architectures. This includes: the use of Transmission Control Protocol/Internet Protocol or Space Communications Protocol Standards for ground and flight communications; the use of knowledge-based control languages; ground and space autonomy; and active endorsement and collaboration in formulating a Space Objects technology for adoption and implementation of plug-and-play components for mission operations. Exploration of the promise of advanced communications technologies and the challenges of satellite constellation operations will continue throughout FY 2001 and FY 2002.

Development for Triana and MAP will be completed in FY 2001; developments will continue for the MIDEX and SMEX series as well as for the HST Servicing Mission 3B. Development efforts on Triana, MAP, EO-1, and similar missions will realize benefits from modern technology, commercial products, and more cost-effective processes (for example, a single system to perform spacecraft integration and test and mission operations; skunkworks development teams; concurrent engineering). The flight dynamics work will continue to be provided in the areas of ground support system development, analysis, and automation tools.

BASIS OF FY 2002 FUNDING REQUIREMENT

TRACKING AND DATA RELAY SATELLITE REPLENISHMENT PROJECT

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Spacecraft Development	[17,700]	[14,468]	57,700
Launch Services	[14,000]	[36,411]	67,800
Total..	[31,700]	[50,879]	125,500

PROGRAM GOALS

The objective of the TDRS Replenishment Project (TDRS H, I, J Spacecraft) is to provide three spacecraft to continue Space Network tracking, data, voice, and video services to NASA scientific satellites, the Space Shuttle, International Space Station, and to other NASA customers. The spacecraft are replacements to the current constellation of geosynchronous TDRS satellites as they begin to exceed their lifetimes. The functional and technical performance requirements for the satellites will be virtually identical to those of the current satellites except for improved multiple access and S-band single access performance, addition of Ka-band, and spacecraft collocation. The three spacecraft will be placed in orbit by expendable launch vehicles (ELV).

STRATEGY FOR ACHIEVING GOALS

The Goddard Space Flight Center manages the development of the TDRS Replenishment Project, and the systems modification of the ground facilities and equipment as necessary to sustain network operations for current and future missions. The three TDRS spacecraft, procured under a fixed-price contract, were awarded to the Hughes Space and Communications Company (now Boeing) in 1995. Lockheed Martin Corporation is the prime contractor for launch services for the TDRS Replenishment Spacecraft.

SCHEDULE AND OUTPUTS

Complete Testing of TDRS-I Plan: June 2001	Complete environmental and functional testing.
Ship TDRS-I to launch site Plan: August 2001	Shipment of TDRS-I to KSC for completion of launch activities

Launch TDRS-I Plan: November 2002	Launch within five years of contract award will be performed, ensuring the continuity of TDRSS services to user space flight systems. This will be the second of three TDRS Replenishment Spacecraft.

ACCOMPLISHMENTS AND PLANS

In FY 2000, the TDRS-H spacecraft was launched successfully. On-orbit checkout of the spacecraft was conducted in July-September 2000. The spacecraft is working well and meets most user service telecommunications performance requirements, except for a minor Multiple Access (MA) anomaly shortfall in performance. An investigation of the MA anomaly began in September 2000. TDRS-I and ¬J integration and test activities continued to progress.

The TDRS-H MA anomaly is planned to be resolved in FY 2001. Changes to the TDRS-I and ¬J spacecraft flight hardware and test program as a result of the MA investigation will be completed prior to the completion of environmental and final functional testing of the spacecraft. The TDRS-I spacecraft will undergo a Pre-Ship Review.

In FY 2002, the TDRS-J spacecraft will have completed environmental and final functional test activities. TDRS-I is scheduled for launch in November 2002. The TDRS-J spacecraft will undergo a Pre-Ship Review and the contractual option to store the spacecraft will be exercised.

BASIS OF FY 2002 FUNDING REQUIREMENT

TECHNOLOGY

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Advanced Communications	[21,300]	[13,371]	10,900
Space Internet	[4,100]	[4,989]	5,300
Virtual Space Presence	[5,300]	[5,288]	5,600
Autonomous Mission Operations	[5,400]	[6,585]	5,000
Advanced Guidance, Navigation, and Control	[4,100]	[5,288]	5,600
Standards		[1,297]	1,400
Technology Program Support		[1,497]	1,600
Total	[40,200]	[38,316]	35,400

PROGRAM GOALS

The objective of the Communications Technology Project (CTP) is to identify, develop, integrate, validate, and transfer/infuse advanced technologies that will increase the performance, provide new capabilities, and reduce the costs of providing data and mission services to the Space Operations customers. Additionally, the CTP infuses new capabilities into commercial practice for the benefit of both NASA and the Nation. Essentially all tasks serve to improve and/or reduce the cost of space operation services, or provide the technology advancement to allow the introduction of new services to the overall Space Communications Architecture.

STRATEGY FOR ACHIEVING GOALS

The SOMO strategy for achieving technology goals is to define five specific campaigns that address unique technology needs across the NASA Enterprises. In defining the activities in each of these campaigns, SOMO works closely with the relevant enterprises to understand their needs and focus on those activities of greatest potential for enabling or enhancing future missions and science. The five campaigns are described below. In addition, funds are requested for Agency standards activities. This provides infusion of new protocols and information system standards to meet space communications and mission operations of NASA and international partners. This budget program support provides funds to cover field center institutional assessments.

Advanced Communication

The focus of this campaign is development of telecommunications technologies to increase data return and decrease costs for support of NASA's missions. The Advanced Communication Campaign is committed to the development of high performance communication technologies for use in future NASA spacecraft and the ground and space assets that support them. The new communication technologies and more efficient implementation schemes will enable or augment future NASA missions with enhanced, lower cost communication services and allow the scientific community to perform more and better research by providing them with access to greater overall communication system bandwidth. The mission of the Advanced Communication Campaign is to identify, develop, and infuse high performance communications technologies necessary to enable or enhance mission data services and to achieve seamless interoperability among NASA, commercial satellite, and terrestrial communications systems.

This campaign has focused work areas supporting the unique low signal levels of Deep Space, high data rates for Near Earth, and low size, weight, power, and cost components for all missions. Activities related to the development and validation of a wide variety of radio frequencies (RF) and optical devices (antennas, receivers, transmitters, modems, and codes) are part of this campaign.

Space Internet

Supporting the Space Communications Architecture vision for transparent operations, the Space Internet Campaign seeks to provide users direct access to tools, payloads, and data. The mission of the Space Internet Campaign is to identify, develop, and infuse Internet and supporting communications infrastructure technologies necessary to achieve seamless interoperability between satellite and terrestrial networks. For Near Earth and near planetary missions, the Space Internet Campaign is committed to the extension of commercially available, terrestrial-based Internet technologies into future NASA spacecraft to enhance the capabilities for remote access and control of space-based assets. Deep Space missions will require new communications protocols and new relay telecommunications. The long round-trip light times, intermittent link availability, and extremely low signal-to-noise ratio (SNR) of deep space links demand carefully tailored protocols to achieve the kinds of high-level file transfer capabilities that we take for granted in today's terrestrial Internet. Within this campaign, we will develop new deep space protocols, test and validate them in protocol testbeds, and infuse them into new radios that provide high-level communication and navigation functionality in low-mass, power-efficient, highly interoperable systems. This campaign also includes activities related to development and validation of space qualifiable code, local area network (LAN), routing, and switching hardware and software.

Virtual Space Presence

As we gather more detailed science information in remote locations, and rely more heavily on robotic exploration and autonomous operations, we must shift how we plan, operate, and visualize these activities. These technologies provide improved science return through several means:

- Advanced data compression techniques and buffer management strategies,
- Advances in on-board processing including feature identification, data mining, fusion, and synthesis operations,

- Other onboard techniques that are coupled with intelligent approaches for information transfer prioritization and management of the limited return link resources.

Advanced tools for high fidelity 3-D visualization of planned and executed spacecraft activities, and the ability to remotely plan activities and display the results, enable distributed team operations and broad outreach by providing secure access to science and mission information resources. This campaign also develops techniques for merging diverse but related data types, and technologies that will allow scientists, and thence the public, to fully visualize and appreciate the value of the returned science products.

Autonomous Mission Operations

This campaign will enable the planning, design, development, and operation of missions with challenging observational or exploration scenarios. These include autonomous decision-making and control for complex navigation and guidance scenarios, collaborative robotic exploration of remote bodies or terrain, autonomous observation planning and optimization of information return, and hazard avoidance and autonomous maintenance of spacecraft operational safety. Model-based system design and operation, goal-oriented planning, and related advanced testing techniques for autonomous systems are essential elements of these approaches. System automation to increase information handling and effective science return, automate system responsiveness to operational activities and spacecraft driven service requests, and automated detection and response to unplanned events are elements of this campaign.

Advanced Guidance, Navigation and Control (GN&C)

Enabling the planning, design, development, and operation of missions with challenging navigation scenarios is the Advanced GN&C Campaign. Scenarios include autonomous navigation and guidance for entry, descent, precision landing, and rendezvous & docking, autonomous formation flying and constellation operations, and operation in complex gravitational fields such as small body or Europa orbits, and Libration points. Many of these mission scenarios require highly responsive guidance approaches with control loops closed on the spacecraft rather than between spacecraft and ground. Autonomous maneuver decision-making, planning, and execution techniques are being extended to enable distributed networks of individual vehicles to interact with one another and act collaboratively as a single functional unit. The activities in this campaign include the techniques and subsystems to enable the relative positions and orientations of vehicles to be determined; formation flying control architectures, strategies, and management approaches; inter-spacecraft communication techniques for constellation coordination; and assess ground/flight operations concepts, trades, and accommodation requirements. Global positioning system (GPS) technologies that have been utilized for applications at the Earth are being evaluated and extended to support autonomous navigation for non-low earth orbit (LEO) missions.

SCHEDULE AND OUTPUTS

Autonomous formation flyer unit complete Plan: 4th Qtr FY 2001 Revised: 1st Qtr FY 2001	Iteration of sensor technology hardware and software system required for multiple spacecraft flying in formation. The Autonomous formation flyer development has been infused into the New Millennium Program's Space Technology 3 (ST-3) program.
Disseminate ACTS experiment results and complete data and record archiving Plan: 4th Qtr FY 2001	Overall experiment results will be catalogued and made available through the ACTS Web Page (http://acts.grc.nasa.gov).
Common Planning and Scheduling System (COMPASS) design review for distributed constellation planning Plan: 4th Qtr FY 2001	COMPASS capability extended to provide flight planning and scheduling in addition to science planning. COMPASS has been incorporated into the Advanced Visual Tools and Architecture Project Build 1 prototype. COMPASS is expected to reduce the cost of mission planning while enabling planning for distributed, independent and/or cooperative observatories (constellations).
Advanced Visual Tools and Architectures (AVATAR) project TAR Build 1 prototype release Plan: 2nd Qtr FY 2001	Zoomable Unit Interface, Data Carousel implemented, and Health Modeling design complete.
Demonstration of Deep Space Station Controller (DSSC) prototype Plan: 4th Qtr FY 2001	Includes model-based health monitoring and diagnosis
Reconfigurable Radio Testbed Demo Plan: 4th Qtr FY 2001	Radio metric navigation and telecommunications between multiple vehicles at Mars.
Optical Communications Technology Laboratory (OCTL) First Light Plan: 1st Qtr FY 2001 Revised: 1st Qtr FY 2002	OCTL development completed and delivery and installation of 1M-diameter telescope at Table Mountain. Performance Validation initiated. The slip for this milestone can be attributed to a delay in the actual placement of the contract, and difficulties in telescope development. No budget growth or customer impact.
Disseminate ACTS experiment results Ka-band TWTA Protoflight model delivery Plan: 3rd Qtr FY 2002	24W EOL Traveling Wave Tube Amplifier with greater than 40% efficiency. A key technology in enabling Ka-band communications.

ACCOMPLISHMENTS AND PLANS

A low power transceiver is being developed for near earth missions which will allow the unit to process up to 12 channels allowing simultaneous Tracking and Data Relay Satellite System (TDRSS) and Global Positioning System (GPS) signal reception. In FY 2000, the Field Programmable Gate Array (FPGA)-based transceiver completed ground-based demonstration of a prototype and is currently scheduled for a Shuttle-based demonstration in FY 2001.

The Advanced Visual Tools and Architectures (AVATAR) project applies visualization technology to spacecraft engineering data analysis in order to increase operator performance in multi-mission, constellation, and lights-out (autonomous operations) environments. The current challenge being addressed by the project is the ability to cost-effectively operate constellations of up to 100 spacecraft.

Key technologies needed to enable utilization of Ka-band communications on future deep space missions will continue. A contract has been awarded for the development of a 27 Watt (24 Watt at end-of-life) space-qualified Ka-band Traveling Wave Tube Amplifier (TWTA) which is more than 40% efficient. Delivery is expected in the third quarter of FY02. The 3m Ka-band reflector array antenna demonstrated last year will be redesigned to enhance its rigidizability and reduce its mass, and a dynamic structural analysis will be performed to assess its expected performance under space flight conditions. A small profile rigid X/Ka-band antenna with high illumination efficiency is also under development. For the ground-receiving end, development of a Ka-band multi-cavity maser low noise amplifier will be demonstrated. Additionally, a combination deformable plate mirror and array feed compensation system will be developed and demonstrated to compensate for large DSN antenna distortions due to gravity and wind buffeting.

Development of the Optical Communications Telescope Laboratory (OCTL) will continue. The 1m-diameter telescope will be delivered and "first light" is planned for first quarter of FY02. The OCTL facility on Table Mountain in California will be used to demonstrate and validate optical communications techniques, components and systems level performance for application to NASA's future high capacity near-Earth and deep-space communications needs. The network of three Atmospheric Visibility Monitoring (AVM) telescopes will continue to collect data, which will be used to assess statistics of optical signal propagation through the atmosphere. Models from these data will be used to evaluate optical link performance for future mission applications.

A software system was developed in FY00 to make real-time position determination anywhere on the Earth to 20 cm resolution. The software uses the Internet to transfer data from multiple GPS receiving sites in real time and to calibrate out error sources in the final position determination. The software was selected by NASA for the FY2000 "Software of the Year" Award.

The Autonomous Formation Flyer development has been infused into the New Millennium Program's Space Technology 3 (ST-3) program. A derivative of the AFF, a software reconfigurable spacecraft transceiver processor prototype, is being developed to provide radio metric navigation and telecommunications between multiple vehicles at Mars. The design will be capable of reconfiguration from the ground through uploads of new software or Field Programmable Gate Array (FPGA) code.

Development of the Deep Space Station Controller (DSSC) prototype will continue and will lead to a demonstration of automated downlink operations in an actual DSN environment. The DSSC is developing an architecture and prototype for achieving station-centric automated control and employs AI-based methods for system health monitoring, diagnosis, and recovery. The monitoring and diagnosis portion of the prototype will employ the BEAM technology, which utilizes a combination of deterministic and stochastic models to monitor system health. Automation of recovery actions is achieved through the Closed-loop Execution and Recovery (CLEaR) technology, which employs continuous planning and execution capabilities. A prototype of the Deep Space Station Controller (DSSC) will be demonstrated in the fourth quarter of FY01.

The ACTS experiments program officially concluded with the ACTS Conference held in conjunction with the 6th International Ka-band Utilization Conference in May 2000. Instead of ceasing all operations and rendering the spacecraft inert, NASA began the process of transferring ACTS to a university-based consortium in early-FY 2001. The intent is to maximize the use of this National asset and benefit space communications education, research and outreach. The consortium is expected to fully fund operations and is to be in place by mid-FY2001. NASA will maintain the operating license and provide minimal oversight of spacecraft operations in exchange for experimental access to the payload to support the communications technology project.

HUMAN SPACE FLGIHT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY & MISSION ASSURANCE
OFFICE OF THE CHIEF ENGINEER
OFFICE OF THE CHIEF TECHNOLOGIST

SAFETY, MISSION ASSURANCE AND ENGINEERING

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002* PRES BUDGET
	(Thousands of Dollars)		
Safety and Mission Assurance	[25,200]	[25,145]	28,700
Engineering	[13,100]	[17,462]	19,100
Advanced Concepts	[4,700]	[4,789]	**
Total	[43,000]	[47,396]	47,800
Distribution of Program Amount by Installation			
Johnson Space Center	[7,142]	[7,625]	8,645
Kennedy Space Center	[914]	[360]	550
Marshall Space Flight Center	[1,760]	[2,962]	3,700
Stennis Space Center	[80]	[150]	315
Ames Flight Research Center	[6,193]	[1,105]	1,245
Dryden Research Center	[334]	[300]	900
Langley Research Center	[5,124]	[5,925]	6,185
Glenn Research Center	[2,501]	[2,298]	2,035
Goddard Space Flight Center	[8,761]	[15,349]	12,690
Jet Propulsion Laboratory	[6,958]	[7,368]	7,705
Headquarters	[3,233]	[3,954]	3,830
Total	[43,000]	[47,396]	47,800

**Beginning in FY 2002, SMA&E will be included in the Human Space Flight Appropriation. FY 2000 and FY 2001 data is for comparison purposes only.*
*** Beginning in FY 2002, Advanced Concepts is funded in the SAT appropriation under Aerospace Technology.*

PROGRAM GOALS

The Safety, Mission Assurance, Engineering, and Advanced Concepts (SMAEAC) area is an investment to enable the safety and success of all NASA programs. The SMAEAC budget supports the activities of the Office of Safety and Mission Assurance (OSMA), the Office of the Chief Engineer (OCE), and the former Office of the Chief Technologist (OCT). The OCT was merged with the Office of Aerospace Technology (OAT) in FY 2000, and OAT continues the former OCT's responsibilities. These Offices advise the Administrator, oversee NASA programs, develop Agency-wide policies and standards, and support the technology requirements of NASA flight programs. Each area is discussed separately.

SAFETY AND MISSION ASSURANCE

STRATEGY FOR ACHIEVING GOALS

The Safety and Mission Assurance (SMA) area assures that sound and robust SMA processes and tools are in place to enable safe and successful missions. This area establishes SMA strategies, policies, and standards, ensures that SMA disciplines are appropriately applied throughout the program life cycle. SMA also provides analysis, oversight, and independent assessment (IA) of programs, and flight and ground operations to ensure that suitable attention is placed on risk, missions are conducted safely, and there is a high probability of meeting Agency objectives. SMA funds research, development, pilot application, and evaluation of tools, techniques, and practices that advance NASA's SMA capabilities in areas such as facility and operational safety, risk management, human reliability, software assurance, and probabilistic risk analysis. Funding is also provided to develop SMA training courses.

ACCOMPLISHMENTS AND PLANS

In FY 2000, NASA achieved a lost time injury rate of 0.22 incidents per 200,000 workhours against a goal of 0.30. The FY 2001 goal is 0.28 lost time incidents per 200,000 workhours. Beginning in FY 2002, NASA uses the Federal Worker 2000 goal of remaining below 1.15 occupational illnesses or injuries per 100 workers.

The OSMA provided SMA support to, and independent review of, the International Space Station (ISS), Space Shuttle (4 missions), and science programs (including 6 expendable launch vehicle (ELV) payload launches) in FY 2000. Also in FY 2000, OSMA instituted an Independent Mission Assurance Review (IMAR) process for ELVs and payloads, similar to the preflight assurance review process for Space Station and Space Shuttle. Independent review of the ISS continues beyond FY 2002. Support and review will be provided to 7 Shuttle and 13 ELV and payload missions in FY 2001, and 7 Shuttle and 8 ELV and payload missions in FY 2002.

FY 2000 research, development, pilot application, and evaluation efforts for SMA tools, techniques and practices in disciplines such as operational and facility safety, risk management, quantitative risk analysis, software assurance, failure detection and prevention, parts assurance, and human reliability had the goal of enabling NASA safety and mission success. Revisions to the NASA Safety Manual; NASA Emergency Preparedness Plan Procedures and Guidelines; NASA Procedures and Guidelines for Mishap Reporting, Investigating, and Recordkeeping; and Government Safety and Mission Assurance Surveillance Functions for NASA Contracts were completed. In FY 2001 and 2002, OSMA will continue to identify, develop, update, and evaluate SMA policies, processes, tools, techniques and practices (including risk management, operational safety, quantitative risk analysis, software assurance, failure detection and prevention, and human reliability) to enable safety and mission success

OSMA completed 3 Center Process Verification Reviews in FY 2000, with more Centers to be reviewed in FY 2001 and 2002. Activities to maintain NASA's third-party ISO 9001 certification continue beyond FY 2002. Safety reviews for Mars missions that will carry nuclear materials were begun in 2001, and reviews of other missions that will carry nuclear materials are anticipated.

ENGINEERING

STRATEGY FOR ACHIEVING GOALS

The OCE oversees the conduct and improvement of NASA's engineering practice, manages the strategic crosscutting process to "Provide Aerospace Products and Capabilities" and independently evaluates ongoing programs, proposed concepts, and options for new programs. The OCE establishes policies, standards, guidance, and support for improving NASA engineering practices and technical capabilities, and manages the NASA Electronics Parts and Packaging Program, which supports evaluation and infusion of advanced electronic parts and packaging technology into NASA programs.

ACCOMPLISHMENTS AND PLANS

In FY 2000, the NASA Integrated Action Team (NIAT) – an activity led by the Office of the Chief Engineer (OCE) -- developed a set of 17 recommendations for improving the overall NASA engineering and program management process. In FY 2001, the Office of the Chief Engineer (OCE) will begin development of an agency-wide systems engineering process that will be piloted and integrated with an updated program management structure in FY 2002. In FY 2000, NASA established policies to improve the software engineering process and provide a continuing basis for raising capability levels. Implementing procedures and metrics will be developed in FY 2001 and piloted in FY 2002.

The NASA Chief Engineer's Office is also undertaking an activity to more quantitatively define and characterize risk on different missions and projects. By linking discussion of acceptable risk to other mission and project variables including cost, schedule and performance, NASA intends to avoid taking on unnecessary risks during the development of critical, operational missions and projects while also avoiding unnecessary and potentially costly risk reduction measures on more experimental missions and projects. NASA intends to fully implement consideration of risk in the definition and development of new missions and projects starting in the FY 2003 budget. Eventually, NASA intends to incorporate consideration of risk at the program level by looking across multiple low- and high-risk projects to examine whether a program has the correct overall risk profile.

Two Independent Assessments of programs in development and 17 Independent Annual Reviews (IARs) of ongoing programs were conducted in FY 2000. Eight Independent Assessments, including several science missions, the ISS Propulsion Module, and Shuttle upgrade projects are anticipated in FY 2001. Both Independent Assessments and IARs will continue at the same level in FY 2002. In FY 2000, an integrated cost estimating capability was established to improve estimating tools and to provide independent cost estimates for specific programs. In FY 2001 independent estimates are planned for three programs and improved models will be implemented; model development and independent estimates will continue in FY 2002. Systems Management Offices were established at each NASA Center to extend the independent evaluation function to the performing Center level.

In FY 2000, NASA completed identification of baseline voluntary consensus standards (VCS) for its NASA Preferred Technical Standards baseline and continues strong support for VCS development, implementing PL 104-113 and OMB A-119. On-line access to many of the adopted standards is available now and full access is planned for FY 2002. FY 2001 pilot initiatives will improve the use of standards include notifying using programs of standards updates and referencing lessons learned to relevant standards; these pilots will be extended NASA wide in FY 2002.

The NASA Electronic Parts and Packaging Program (NEPP) performs radiation testing, technology evaluation, and application readiness assessments of advanced electronics components and packaging technologies. In FY 2000, an integrated World Wide Web site was developed to make results of these evaluations available to users. Considerable emphasis is being placed on evaluation and infusing of "commercial off the shelf" technologies where they meet space reliability and performance requirements; guidance on use of new technologies was provided to several current programs in FY 2000. Continuing technology evaluations in FY 2001 will include advanced microprocessors, photonics, and extreme hi/low temperature behavior of components. In FY 2001, evaluations will include advanced sensor technologies, extremely low power devices, and high-density substrates.

ADVANCED CONCEPTS

STRATEGY FOR ACHIEVING GOALS

The Office of Aerospace Technology (OAT) is NASA's principal advocate for advanced technology. As such, the OAT advises the Administrator on technology matters and develops a NASA-wide investment strategy for innovative and advanced technology. The office leads the development of NASA-wide technology goals and objectives and oversees NASA technology policies, programs, processes, and capabilities. OAT also sponsors the NASA Institute for Advanced Concepts (NIAC), which addresses NASA strategic objectives requiring technology readiness ten to twenty years into the future. Funding for Advanced Concepts activities is recorded in the OAT budget beginning with FY 2002.

ACCOMPLISHMENTS AND PLANS

The NASA Institute for Advanced Concepts (NIAC) has completed the third full year of operation and all functions of the Institute have been fully implemented. During FY 2000 the NIAC awarded 6 Phase II contracts and 16 Phase I grants. Five additional Phase II awards have been made in FY 2001. Since the beginning of the contract, NIAC has awarded 46 Phase I grants and 16 Phase II contracts for a total value of $8.6 million. These awards to universities, small businesses, small disadvantaged businesses and large businesses were for the development of revolutionary advanced concepts that may have a significant impact on NASA's future aeronautics and space missions. For example, the *Mini-Magnetospheric Plasma Propulsion (M2P2)* System, which uses the solar wind for propulsion, is receiving additional funding from NASA's Marshall Space Flight Center (MSFC) and funds have been allocated for follow-on tests and analysis for its space propulsion application. Moreover, it has the potential to provide shielding from cosmic ray radiation. A concept for *Very large optics for the Study of Extrasolar Terrestrial Planet* has collaboration with NASA's Goddard Space Flight Center (GSFC) and MSFC and is directly connected to long term space science goals to image planets around other stars. A concept for a large *X-Ray Interferometry* has collaboration with GSFC and is directly connected with long term space science goals to study the structure and evolution of the universe. Other ongoing studies include using a constellation of steerable balloons for atmospheric studies and biologically inspired robotics. Also, during FY 2001 the next set of Phase I awards will be made and solicitations will be released for the next round of Phase I and Phase II awards.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

GENERAL STATEMENT

GOAL STATEMENT

The Science, Aeronautics and Technology appropriation provides funding for the research and development activities of NASA. This includes funds to extend our knowledge of the Earth, its space environment, and the universe; and to invest in new aerospace transportation technologies that support the development and application of technologies critical to the economic, scientific and technical competitiveness of the United States.

In FY 2000 and FY 2001, the SAT account provided only for the *direct* funding of science, aeronautics and technology activities, and funding for space operations services. Beginning in FY2002, the SAT account includes the direct funding of science and aeronautics research and technology *plus* other related costs (Research and Program Management and non-programmatic Construction of Facilities) that are allocated based on the number of full time equivalent personnel. There will no longer be a Mission Support account. In addition, beginning in FY 2002, funding for Space Operations Services is included in the Human Space Flight account.

In FY 2002, the Science, Aeronautics and Technology (SAT) appropriation provides for the science, aeronautics and technology activities supporting the Agency. These activities include space science, biological and physical research, Earth science, aerospace technology, and academic programs. This appropriation also provides for salaries and related expenses (including travel); design, repair, rehabilitation, and modification of facilities and construction of new facilities; maintenance, and operation of facilities; and other operations activities supporting science, aeronautics, and technology programs.

STRATEGY FOR ACHIEVING GOALS

Funding included in the Science, Aeronautics and Technology appropriation supports the program elements of four out of NASA's five Enterprises:

> Space Science - seeks to answer fundamental questions concerning the galaxy and the universe; the connection between the Sun, Earth and heliosphere; the origin and evolution of planetary systems; and, the origin and distribution of life in the universe.

Biological and Physical Research - seeks answers to questions that are basic to the future of humanity, regarding how the fundamental laws of nature shape the evolution of life, and how human existence might expand beyond the home planet to achieve maximum benefits from space. This line item replaces the Life and Microgravity line item in previous budgets.

Earth Science - seeks to understand the total Earth system and the effects of natural and human-induced changes on the global environment.

Aerospace Technology - pioneers high-payoff, critical technologies with effective transfer of design tools and technology products to industry and government.

Funding is also included to provide highly reliable, cost effective telecommunications services in support of NASA's science and aeronautics programs, and to conduct NASA's agency-wide university, minority university, and elementary and secondary school programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

		BUDGET PLAN	
	FY 2000 OPLAN Revised	FY 2001 OPLAN Revised	FY 2002 PRES BUDGET
SCIENCE, AERONAUTICS AND TECHNOLOGY	**5,672.1**	**6,177.1**	**7,191.7**
SPACE SCIENCE	2,193.8	2,321.0	2,786.4
BIOLOGICAL & PHYSICAL RESEARCH	274.7	312.9	360.9
EARTH SCIENCE	1,443.4	1,484.6	1515.0
AERO-SPACE TECHNOLOGY	985.4	1,241.7	2,228.8
COMMERCIAL TECHNOLOGY	140.0	162.4	146.9
MISSION COMMUNICATION SERVICES	406.3	--	--
SPACE OPERATIONS	--	521.8	--
ACADEMIC PROGRAMS	138.8	132.7	153.7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SCIENCE, AERONAUTICS AND TECHNOLOGY
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses, not otherwise provided for, in the conduct and support of science, aeronautics and technology research and development activities, including research, development, operations, *support* and services; maintenance; construction of facilities including *repair, rehabilitation,* revitalization and modification of facilities, construction of new facilities and additions to existing facilities, facility planning and design, *environmental compliance and restoration*, and acquisition or condemnation of real property, as authorized by law; space flight, spacecraft control and communications activities including operations, production, and services; *program management; personnel and related costs, including uniforms or allowances therefor, as authorized by 5 U.S.C. §§ 5901- 5902; travel expenses; purchase and hire of passenger motor vehicles; not to exceed $20,000 for official reception and representation expenses;* and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, [$6,190,700,000] *$7,191,700,000*, to remain available until September 30, [2002] 2003, *of which amounts as determined by the Administrator for salaries and benefits; training, travel and awards; facility and related costs; information technology services; science, engineering, fabricating and testing services; and other administrative services may be transferred to the Human Space Flight account in accordance with section 312(b) of the National Aeronautics and Space Act of 1958, as amended by Public Law 106-377. (Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2001, as enacted by section 1(a)(1) of P.L-106-377.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SCIENCE, AERONAUTICS AND TECHNOLOGY

REIMBURSABLE SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 2000 OPLAN Revised	FY 2001 OPLAN Revised	FY 2002 PRES BUDGET
SCIENCE, AERONAUTICS AND TECHNOLOGY	**432.1**	**600.3**	**615.6**
SPACE SCIENCE	45.2	54.1	84.2
LIFE AND MICROGRAVITY SCIENCES AND APPLICATIONS	0.4	--	--
BIOLOGICAL AND PHYSICAL RESEARCH	--	0.5	0.8
EARTH SCIENCE	318.4	383.9	415.9
AEROSPACE TECHNOLOGY	48.2	69.3	64.9
COMMERICAL TECHNOLOGY	16.5	26.7	18.9
MISSION COMMUNICATION SERVICES	3.1	--	--
SPACE OPERATIONS	--	65.4	--
ACADEMIC PROGRAMS	0.3	0.4	0.4
RESEARCH AND PROGRAM MANAGEMENT	--	--	30.2
CONSTRUCTION OF FACILITIES	--	--	0.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES

DISTRIBUTION OF SCIENCE, AERONAUTICS, AND TECHNOLOGY BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Glenn Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Space Science	2000	2,193,800	24,738	135,929	149,594	35	103,015	75	13,882	28,633	803,618	826,855	107,426
	2001	2,320,989	14,081	127,566	148,898	35	71,427	75	8,694	2,670	857,896	957,761	131,886
	2002	2,786,363	21,505	165,263	191,620	2,054	101,743	188	21,483	7,639	1,164,043	978,719	132,106
Biological and Physical Research	2000	274,700	106,822	6,752	48,498	0	32,767	0	52	39,397	11,757	10,793	17,862
	2001	312,910	124,215	5,349	58,713	0	49,875	0	35	36,917	4,317	14,706	18,783
	2002	360,920	120,888	7,678	87,775	0	48,344	0	269	49,883	2,087	13,586	30,410
Earth Science	2000	1,443,400	36,218	60,985	17,642	49,127	26,342	21,883	93,179	1,917	871,371	230,961	33,775
	2001	1,484,627	33,066	80,798	18,478	67,290	19,004	20,142	118,283	2,707	879,136	204,394	41,329
	2002	1,514,978	18,552	68,708	27,567	43,159	30,273	25,317	143,912	1,375	895,357	180,667	80,091
Aero-Space Technology	2000	985,395	2,698	6,716	202,934	36,738	203,249	100,618	193,131	186,105	6,194	6,284	40,728
	2001	1,241,658	7,839	7,894	231,220	27,563	272,572	99,857	246,687	238,361	27,581	28,745	53,339
	2002	2,228,839	9,968	31,910	444,926	36,074	448,454	141,983	482,026	391,287	43,440	36,175	162,596
Commercial Technology Programs	2000	140,005	14,242	6,392	17,121	5,000	15,428	4,200	17,741	25,513	29,668	2,916	1,784
	2001	162,442	15,094	6,255	16,017	4,714	14,569	3,921	17,075	28,403	32,398	4,790	19,205
	2002	146,900	14,196	6,609	16,504	4,977	14,256	4,200	18,018	23,395	39,931	2,867	1,947
Total Aero-Space Technology	2000	1,125,400	16,940	13,108	220,055	41,738	218,677	104,818	210,872	211,618	35,862	9,200	42,512
	2001	1,404,100	22,933	14,149	247,237	32,277	287,141	103,778	263,762	266,764	59,979	33,535	72,544
	2002	2,375,739	24,164	38,519	461,430	41,051	462,710	146,183	500,044	414,682	83,371	39,042	164,543
Mission Communication Services	2000	406,300	172,500	1,100	800	0	0	12,800	0	10,100	71,500	131,700	5,800
	2001	0	0	0	0	0	0	0	0	0	0	0	0
	2002	0	0	0	0	0	0	0	0	0	0	0	0
Space Operations	2000	0	0	0	0	0	0	0	0	0	0	0	0
	2001	521,743	225,593	37,111	8,800	0	0	12,743	0	8,990	92,071	113,016	23,419
	2002	0	0	0	0	0	0	0	0	0	0	0	0
Academic Programs	2000	138,800	6,918	3,785	7,619	2,965	5,193	1,582	2,221	9,647	82,671	2,032	14,167
	2001	132,707	3,070	3,066	6,821	1,781	4,363	1,369	3,504	6,322	87,543	798	14,070
	2002	153,700	2,198	2,593	7,130	1,500	4,450	1,750	4,333	4,942	109,877	800	14,127
TOTAL SCIENCE, AERONAUTICS AND TECHNOLOGY	2000	5,582,400	364,136	221,659	444,208	93,865	385,994	141,158	320,206	301,312	1,876,779	1,211,541	221,542
	2001	6,177,076	422,958	268,039	488,947	101,383	431,810	138,107	394,278	324,370	1,980,942	1,324,210	302,031
	2002	7,191,700	187,307	282,761	775,522	87,764	647,520	173,438	670,041	478,521	2,254,735	1,212,814	421,277

SCIENCE, AERONAUTICS AND TECHNOLOGY

FY 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE **SPACE SCIENCE**

SUMMARY OF RESOURCE REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
* Chandra X-ray Observatory	4,100			SAT 1-6
* Space Infrared Telescope Facility....................................	123,400	118,339	105,900	SAT 1-7
* Hubble Space Telescope (Development)	183,500	179,504	161,800	SAT 1-10
* Relativity (GP-B) Mission	49,900	41,209	40,200	SAT 1-12
* Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)	27,500	13,280	--	SAT 1-15
* Stratospheric Observatory For Infrared Astronomy	42,000	38,914	37,000	SAT 1-17
* Solar Terrestrial Relations Observatory (STEREO)	[8,300]	[21,900]	50,300	SAT 1-20
* Gamma-ray Large Area Space Telescope (GLAST)	[4,900]	[4,700]	19,400	SAT 1-22
Payload and Instrument Development...............................	14,450	33,426	44,800	SAT 1-24
* Explorers..	122,500	141,288	155,000	SAT 1-28
* Discovery	150,300	212,973	217,100	SAT 1-35
* Mars Exploration..	248,800	427,564	430,900	SAT 1-39
Mission Operations	78,700	85,303	105,300	SAT 1-44
Technology Program..	581,200	419,245	478,800	SAT 1-50
Research Program...	567,450	596,773	606,500	SAT 1-70
Investments	[10,200]	13,171	--	SAT 1-76
[Construction of Facilities - included above]	[2,500]	[7,200]	[20,500]	
Institutional Support	[330,369]	[303,675]	333,362	SAT 1-77
Total..	2,193,800	2,320,989	2,786,362	

*Total Cost information is provided in the Special Issues section

SCIENCE, AERONAUTICS AND TECHNOLOGY

FY 2002 ESTIMATES

BUDGET SUMMARY

Distribution of Program Amount by Installation	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Johnson Space Center	24,738	14,081	21,505
Kennedy Space Center	135,929	127,566	165,263
Marshall Space Flight Center	149,594	148,898	191,620
Ames Research Center	103,015	71,427	101,742
Langley Research Center	13,882	8,694	21,483
Glenn Research Center	28,633	2,670	7,639
Goddard Space Flight Center	803,618	857,896	1,164,043
Jet Propulsion Laboratory	826,855	957,761	978,719
Dryden Flight Research Center	75	75	188
Stennis Space Center	35	35	2,054
Headquarters	107,426	131,886	132,106
Total	2,193,800	2,320,989	2,786,362

PROGRAM GOALS

Humans have a profound and distinguishing imperative to understand our origin, our existence, and our fate. For millennia, we have gazed at the sky, observed the motions of the Sun, Moon, planets, and stars, and wondered about the universe and the way we are connected to it. The Space Science Enterprise serves this human quest for knowledge. As it does so, it seeks to inspire our Nation and the world, to open young minds to broader perspectives on the future, and to bring home to every person on Earth the experience of exploring space.

The mission of the Space Science Enterprise is to solve mysteries of the universe, explore the solar system, discover planets around other stars, and search for life beyond Earth; from origins to destiny, chart the evolution of the universe and understand its galaxies, stars, planets, and life. In pursuing this mission, we develop, use, and transfer innovative space technologies that provide scientific and other returns to all of NASA's Enterprises, as well as globally competitive economic returns to the Nation. We also use our knowledge and discoveries to enhance science, mathematics, and technology education and the scientific and technological literacy of all Americans.

In accomplishing its mission, the Space Science Enterprise addresses most directly the following NASA fundamental questions:

How did the universe, galaxies, stars, and planets form and evolve? How can our exploration of the universe and our solar system revolutionize our understanding of physics, chemistry, and biology?

Does life in any form, however simple or complex, carbon-based or other, exist elsewhere than on planet Earth? Are there Earth-like planets beyond our solar system?

The four long-term goals of the Space Science Enterprise are:

Establish a virtual presence throughout the solar system, and probe deeper into the mysteries of the universe and life on Earth and beyond—a goal focused on the fundamental science we will pursue;

Pursue space science programs that enable, and are enabled by, future human exploration beyond low-Earth orbit—a goal exploiting the synergy with the human exploration of space;

Develop and utilize revolutionary technologies for missions impossible in prior decades—a goal recognizing the enabling character of technology; and

Contribute measurably to achieving the science, mathematics, and technology education goals of our nation, and share widely the excitement and inspiration of our missions and discoveries—a goal reflecting our commitment to education and public outreach.

STRATEGY FOR ACHIEVING GOALS

Science

In the Space Science Enterprise we pursue the study of origins, as well as studies of the evolution and destiny of the cosmos, by establishing a continuum of exploration and science. We create a virtual presence in the solar system, exploring new territories and investigating the solar system in all its complexity. We simultaneously probe the universe to the beginning of time, looking ever deeper with increasingly capable telescopes, scanning the entire electromagnetic spectrum from gamma rays to radio wavelengths. We also send probes into interstellar space, beginning a virtual presence even beyond the solar system.

The strategy of the Enterprise is to conduct world-class research, to maximize the scientific yield from our current missions, and to develop and deploy new missions within the "faster, better, cheaper" framework of a revolutionized NASA.

A key aspect of our strategic planning is to acquire the advice of the external science community, and in particular the National Academy of Sciences. The Enterprise also ensures science community input by utilizing peer review as broadly as possible. In addition, there is extensive collaboration with the science community, international partners, and other federal agencies, such as the National Science Foundation, Department of Defense, and Department of Energy, in the conduct of our missions, research and technology.

As a visible link to future human exploration beyond Earth orbit, Space Science Enterprise robotic missions help develop the scientific knowledge such ventures will need. In the long term, the Enterprise will benefit from the opportunities human exploration will offer to conduct scientific research that may stretch beyond the capabilities of robotic systems.

Education and public outreach

The traditional role of the Space Science Enterprise in supporting graduate and postgraduate professional education — a central element of meeting our responsibility to help create the scientific workforce of the future — is being expanded to include a special emphasis on pre-college education and on increasing the public's knowledge, understanding, and appreciation of science and technology. The comprehensive approach to education and public outreach developed by the Space Science Enterprise is described in more detail in the October 15, 1996 report "Implementing the Office of Space Science Education/Public Outreach Strategy", available in full on the World Wide Web at http://spacescience.nasa.gov/edu/imp_plan.htm

Our strategy begins with incorporating education and public outreach as an integral component of all of our activities — flight missions and research programs. It focuses on identifying and meeting the needs of educators and on emphasizing the unique contributions the Space Science Enterprise can make to education and to enhancing the public understanding of science and technology. During FY 2002, we will successfully achieve at least six of the following eight objectives:

(1) Ensure that every mission initiated in FY 2002 has a funded E/PO program, with a comprehensive E/PO plan prepared by its Critical Design Review (CDR).
(2) Ensure that by the end of FY 2002, ten percent of all research grants have an associated E/PO program underway.
(3) Plan and/or implement Enterprise-funded E/PO activities taking place in at least forty states.
(4) Ensure that at least ten Enterprise-funded research, mission development, mission operations, or education projects are underway in Historically Black Colleges and Universities, Hispanic Serving Institutions, and Tribal Colleges, with at least three being underway in an institution of each type.
(5) Provide exhibits, materials, workshops, and personnel at a minimum of five national and three regional education and outreach conferences.
(6) Ensure that at least ten major Enterprise-sponsored exhibits or planetarium shows will be on display or on tour at major science museums or planetariums across the country.
(7) Prepare the second comprehensive Space Science Education/Outreach Report describing participants, audiences, and products for Enterprise E/PO programs.
(8) Initiate a major external review of the accomplishments of the Space Science E/PO efforts over the past five years, and complete development of the first phase of a comprehensive approach to assessing the E/PO program’s long-term effectiveness and educational impact. When completed, the results of both studies will be used to guide further adjustments in program direction and content.

Technology development and transfer

A number of enabling technologies have been identified for the Space Science program, and prioritizing them is one of the most important technology planning tasks. These technologies fall into two general categories:

- Technologies that provide fundamental capabilities without which certain objectives cannot be met, or that open completely new mission opportunities. Fundamental enabling capabilities include developments such as high-precision deployable structures that maintain optical paths to within fractions of a wavelength of light. These are required for studying extra-solar planets through optical interferometry, as well as for the next generation of large space telescopes that will see to the edge of the Universe.

- Technologies that reduce cost and/or risk to such a degree that they enable missions that would otherwise be economically unrealistic. Highly capable microelectronics and micro-spacecraft systems, by virtue of their broad applicability and potential for reducing mission costs and development times, enable missions, which would otherwise be prohibitively expensive. The importance of these systems and their commercial potential make them one of our most important technology investment areas.

A well-structured technology portfolio must recognize and balance the importance of both categories. A key aspect of this portfolio is that it utilizes partnerships with industry, other government agencies and universities in the planning, development and implementation of Space Science missions. Many capabilities have been transferred and infused into industry from DoD or NASA core technology support, and the space industry has also incorporated technological advances from throughout our economy, particularly in information technology. The space science research community uses the resulting industrial space infrastructure for mission planning and development. Industry partnerships allow for a more efficient linkage between the builders and users of flight hardware. The identification, development and utilization of advanced technology dramatically lowers instrument, spacecraft, and mission operations costs and contributes to the long-term capability and competitiveness of American industry.

BASIS OF FY 2002 FUNDING REQUIREMENT

CHANDRA X-RAY OBSERVATORY

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Chandra X-ray Observatory development *	4,100		

* Total cost information is provided in the Special Issues section

PROGRAM GOALS

The Chandra X-ray Observatory (CXO, formerly the Advanced X-ray Astrophysics Facility, AXAF) is the third of NASA's Great Observatories, which include the Hubble Space Telescope and the Compton Gamma Ray Observatory. CXO observes matter at the extremes of temperature, density and energy content. With its unprecedented capabilities in energy coverage, spatial resolution, spectral resolution and sensitivity, CXO is providing unique and crucial information on the nature of objects ranging from nearby stars to quasars at the edge of the observable universe.

STRATEGY FOR ACHIEVING GOALS

The Marshall Space Flight Center (MSFC) was assigned responsibility for managing AXAF in 1978 as a successor to the High-Energy Astrophysics Observatory (HEAO) program. The scientific payload was selected through an Announcement of Opportunity (AO) in 1985 and confirmed for flight readiness in 1989.

The AXAF program was restructured in 1992 in response to decreasing future funding projections for NASA programs. The original baseline was an observatory with six mirror pairs, a 15-year mission in low-Earth orbit, and Shuttle servicing. The restructuring produced AXAF-I, an observatory with four mirror pairs to be launched into a high-Earth orbit for a five-year lifetime, and AXAF-S, a smaller observatory flying an X-Ray Spectrometer (XRS). A panel from the National Academy of Sciences (NAS) endorsed the restructured AXAF program. Congress reduced the FY 1994 AXAF budget, resulting in termination of the AXAF-S mission. The Committees further directed that residual FY 1994 AXAF-S funds be applied towards development of a similar instrument for flight on the Japanese Astro-E mission. Astro-E was launched by Japan in February 2000, but failed to achieve orbit.

In December 1998 NASA announced that AXAF had been renamed the Chandra X-ray Observatory, in honor of the late Indian-American Nobel laureate, Subrahmanyan Chandrasekhar. CXO was launched successfully by the Space Shuttle and an Inertial Upper Stage on July 23, 1999. Following launch, the spacecraft entered a period of checkout, followed by the start of science operations. The observatory is functioning superbly, and the science results have been spectacular, as reported below within the Data Analysis section of the Research budget. Current information is available on their web site at http://chandra.harvard.edu

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE INFRARED TELESCOPE FACILITY

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
SIRTF development *..	123,400	118,339	105,900

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The purpose of the Space Infrared Telescope Facility (SIRTF) mission is to explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. These windows allow infrared observations to explore the cold Universe by looking at heat radiation from objects which are too cool to radiate at optical and ultraviolet wavelengths; to explore the hidden Universe by penetrating into dusty regions which are too opaque for exploration in the other spectral bands; and to explore the distant Universe by virtue of the cosmic expansion, which shifts the ultraviolet and visible radiation from distant sources into the infrared spectral region. To exploit these windows requires the full capability of a cryogenically cooled telescope, limited in sensitivity only by the faint infrared glow of the interplanetary dust.

SIRTF is optimized to attack the scientific questions listed below. The first four questions identify the four primary science programs of the SIRTF mission. The fifth question identifies the potential for serendipitous discoveries using SIRTF.

1. How do galaxies form and evolve? SIRTF's deep surveys will determine how the number and properties of galaxies changed during the earliest epochs of the Universe.

2. What engine drives the most luminous objects in the Universe? SIRTF will study the evolution over cosmic time of ultraluminous galaxies and quasar populations and probe their interior regions to study the character of their energy sources.

3. Is the mass of the Galaxy hidden in sub-stellar objects and giant planets? SIRTF will search for cold objects with mass less than 0.08 that of the Sun, not massive enough to ignite nuclear reactions, which may contain a significant fraction of the mass of the Galaxy.

4. Have planetary systems formed around nearby stars? SIRTF will determine the structure and composition of disks of material around nearby stars whose very presence implies that these stars may harbor planetary systems.

5. What lies beyond? SIRTF's greater than 1000-fold gain in astronomical capability beyond that provided by previous infrared facilities gives this mission enormous potential for the discovery of new phenomena.

While these scientific objectives drive the mission design, SIRTF's powerful capabilities have the potential to address a wide range of other astronomical investigations. SIRTF should be able to achieve many of the initial goals of the Origins program; SIRTF's measurements of the density and opaqueness of the dust disks around nearby stars will help set the requirements for future Origins missions designed to directly detect planets.

STRATEGY FOR ACHIEVING GOALS

The Jet Propulsion Laboratory (JPL) was assigned responsibility for managing the SIRTF project. The SIRTF Mission is composed of six major system elements and components as described below. The first three elements (the Science Instruments, Cryo/Telescope Assembly, and Spacecraft Assembly) will be assembled into a single space-based observatory system by means of the fourth element -- System Integration and Test. The fifth element is the launch vehicle, and the sixth is the ground system, which will be used to operate the Observatory on the ground prior to launch, and in space to achieve the mission objectives.

Science Instruments are being provided by three Principal Investigators (PIs) selected by NASA in 1984 in response to a NASA Announcement of Opportunity. The three science instruments and their PIs are: the Infrared Array Camera (IRAC), Smithsonian Astrophysical Observatory, Dr. Giovanni Fazio; the Infrared Spectrometer (IRS), Cornell University, Dr. James Houck; and the Multiband Imaging Photometer for SIRTF (MIPS), University of Arizona, Dr. George Rieke.

Ball Aerospace and Technologies Corporation, Boulder, CO, as an industrial member of the SIRTF Integrated Project Team, is developing the Cryo/Telescope Assembly (CTA). The CTA consists of all of the elements of SIRTF that will operate in space at reduced or cryogenic temperatures, including the telescope, telescope cover, cryostat, and supporting structures and baffles. The cryostat will contain the cold portions of the PI-provided Science Instruments.

Lockheed Martin Missiles and Space, Sunnyvale, CA, as an industrial member of the SIRTF Integrated Project Team, is developing the Spacecraft Assembly. The spacecraft assembly consists of all of the elements of SIRTF that are needed for power, data collection, Observatory control and pointing, and communications. These elements of SIRTF are nominally operated at or near 300 degrees Kelvin, and will also include the warm portions of the PI-provided Science Instruments.

System Integration and Test (SIT) has been identified as a separate system element, and is being provided by Lockheed Martin Missiles and Space, Sunnyvale, CA, as an industrial member of the SIRTF Integrated Project Team. This element will complete the assembly of the Observatory using the science instruments, the CTA, and the Spacecraft Assembly. System level verification and testing, launch preparations and launch of SIRTF are being performed by this element.

Flight and Science and Operations System development are being accomplished in parallel with Observatory development. This is being done to reduce redundant development of ground equipment and software and to assure compatibility between the ground systems and the Observatory after launch. The mission development team at JPL is developing the Flight Operations segment (FOS). The Science Operations Segment (SOS) is being developed by the SIRTF Science Center, located at California Institute of Technology's (Cal Tech) Infrared Processing Analysis Center (IPAC).

SCHEDULE & OUTPUTS

Instrument Development Plan: April 2000 Actual: December 2000	Deliver the Infrared Array Camera (IRAC), Multiband Imaging Photometer (MIPS), and Infrared Spectrograph (IRS) instruments. The instruments will perform at their specification levels at delivery. Delivery of IRAC was delayed until December 2000 due to hardware problems and completion of software development activities. The MIPS and IRS instruments were delivered on time.
Complete Spacecraft Plan: 2nd Qtr FY 2001 Revised: 3rd Qtr FY 2001	Complete the SIRTF Spacecraft and have it ready for integration with the Cryogenic Telescope Assembly (CTA).
Complete CTA Plan: 2nd Qtr FY 2001 Revised: 1st Qtr FY 2002	Complete the SIRTF Cryogenic Telescope Assembly (CTA), and deliver it to the spacecraft contractor for integration with the spacecraft. Revised due to delay in delivery of IRAC instrument (see above).
Integration & Test Plan: FY 2002	Complete integration and test of spacecraft and payload.

ACCOMPLISHMENTS AND PLANS

The flight model of the cryostat was completed on schedule in October 1999. As a result of the late delivery of the IRAC instrument, launch has been delayed from December 2001 until July 2002. All instruments have now been integrated into the cryostat and are working as designed. The Telescope Acceptance Review was completed in January 2001; the Telescope meets or exceeds all Level 1 requirements. A major flight software build was delivered and successfully tested in February 2001. As work continues in FY 2001-2002, the Spacecraft and CTA will be completed, consistent with the new launch schedule.

BASIS OF FY 2002 FUNDING REQUIREMENT

HUBBLE SPACE TELESCOPE DEVELOPMENT

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Hubble Space Telescope Development...............................	183,500	179,504	161,800

PROGRAM GOALS

The goal of the Hubble Space Telescope (HST) development activity is to provide new flight hardware, subsystems, and instruments to extend the telescope's operational life and to enhance its capabilities. HST was launched in April 1990 aboard the Space Shuttle. It is the first and flagship mission of NASA's Great Observatories program, and it is designed to complement the wavelength capabilities of the other spacecraft in the program (CGRO, CXO, and SIRTF). HST is the only one of those observatories that can be serviced and upgraded on orbit. HST is a 2.4-meter telescope capable of performing observations at visible, near-ultraviolet, and near-infrared wavelengths. This program is a joint endeavor of NASA and the European Space Agency (ESA), which provided the faint object camera and the HST's solar arrays. HST is a general observer facility with a worldwide user community.

STRATEGY FOR ACHIEVING GOALS

HST was designed to be serviceable and requires on-orbit maintenance and replacement of spacecraft subsystems and scientific instruments about every three years. Ongoing modification and upkeep of system ground operations are also performed. Information regarding the launch of HST and the first three servicing missions (SM-1 in December 1993, SM-2 in February 1997, and SM-3A in December 1999) is available on-line at http://hubble.gsfc.nasa.gov/servicing-missions/ .

The fourth servicing mission, SM-3B, will install the new Advanced Camera for Surveys (ACS) instrument, which is chiefly designed for survey-mode photographs and discovery. It is estimated that ACS will increase Hubble's survey capability tenfold. SM-3B will also install a new set of solar arrays and a cooling system to extend the life of the NICMOS instrument, plus perform other repairs.

Two new science instruments are scheduled for installation during the final HST Servicing Mission (SM-4). The Cosmic Origins Spectrograph (COS) is a medium-resolution spectrograph specifically designed to observe into the near- and mid-ultraviolet. The ultraviolet region is particularly interesting for observing high-energy activities such as are found in new hot stars and Quasi Stellar Objects (QSO's). The Wide Field Camera Three (WFC3) will be HST's last main imaging camera. WFC3 will be a replacement for WF/PC-2, to maintain the quality of imaging capabilities throughout the life of the HST mission.

Following SM-4, NASA plans to operate HST until 2010, or until subsystem failures render the Observatory inoperable.

SCHEDULE & OUTPUTS

Observatory Upgrades/SM-3 Plan: May 2000 FY 2001 Budget: Actual/Revised: December 1999 and July 2001 FY 2002 Budget: Actual/Revised: December 1999 and May 2002	The third Servicing Mission (SM) was split into two missions, SM-3A in December 1999, and SM-3B, now scheduled to occur no later than May 2002.
HST SM-3A Plan: October 1999 Actual: December 1999	The third Servicing Mission (SM) was split into two missions, SM-3A in December 1999, and SM-3B by July 2001. SM-3A replaced all six gyroscopes, the spacecraft computer, and other hardware items.
HST SM-3B Plan: July 2001 Revised: May 2002	Install two key HST upgrades on Servicing Mission 3B: Advanced Camera for Surveys (ACS) and Solar Array 3 (SA3). HST hardware will be ready to support launch as early as November 2001; the actual launch date will depend upon Shuttle availability.
COS System Test Plan: FY 2002	Begin system test of the Cosmic Origins Spectrograph (COS).

ACCOMPLISHMENTS AND PLANS

HST continues to operate at the forefront of astronomical research. Some of HST's recent scientific results are described under the Data Analysis portion of the Supporting Research and Technology section of this document. All plans for Servicing Mission 3B are on track. Testing of the Advanced Camera for Surveys (ACS) science instrument, the replacement solar arrays, and other components is ongoing, in preparation for delivery to KSC as early as summer of 2001. The launch date will depend on availability of the Space Shuttle but will occur no earlier than November 2001.

Hardware development for SM-4 has also been progressing well. During FY 2002, the hardware will undergo a variety of tests, and plans for the sequence of tasks to be performed during the servicing mission will be refined.

BASIS OF FY 2002 FUNDING REQUIREMENT

RELATIVITY MISSION

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
GP-B Development *..	49,900	41,209	40,200

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The purpose of the Relativity Mission (also known as Gravity Probe-B) is to verify Einstein's theory of general relativity. This is the most accepted theory of gravitation and of the large-scale structure of the Universe. General relativity is a cornerstone of our understanding of the physical world, and consequently of our interpretation of observed phenomena. However, it has only been tested through astronomical observation and Earth-based experiments. An experiment is needed to explore more precisely test the predictions of the theory in two areas: (1) a measurement of the "dragging of space" by rotating matter; and (2) a measurement of space-time curvature known as the "geodetic effect". The dragging of space has never been measured, and the geodetic effect needs to be measured more precisely. Whether the experiment confirms or contradicts Einstein's theory, its results will be of the highest scientific importance. The measurements of both the frame dragging and geodetic effects will allow Einstein's Theory to be either rejected or given greater credence. The effect of invalidating Einstein's theory would be profound, and would call for major revisions of our concepts of physics and cosmology.

In addition, the Relativity Mission is contributing to the development of cutting-edge space technologies that are also applicable to future space science missions and transportation systems.

STRATEGY FOR ACHIEVING GOALS

This test of the general theory requires advanced applications in superconductivity, magnetic shielding, precision manufacturing, spacecraft control mechanisms, and cryogenics. The Relativity Mission spacecraft will employ super-precise quartz gyroscopes (small quartz spheres machined to an atomic level of smoothness) coated with a super-thin film of superconducting material (needed to be able to "read-out" changes in the direction of spin of the gyros). The gyros will be encased in an ultra-low magnetic-shielded, supercooled environment (requiring complex hardware consisting of lead-shielding, a dewar containing supercooled helium, and a sophisticated interface among the instrument's telescope, the shielded instrument probe, and the dewar). The system will maintain a level of instantaneous pointing accuracy of 20 milliarcseconds (requiring precise star-tracking, a "drag free" spacecraft control system, and micro-precision thrusters). The combination of these technologies will enable the Relativity Mission to measure: (1) the distortion caused by the movement of the Earth's gravitational field as the Earth rotates west to east; and, (2) the distortion caused by the movement of the Relativity Mission spacecraft through the Earth's gravitational field south to north, to a level of precision of 0.5 milliarcsecond per year (the width of a human hair observed from 16 miles).

The expertise to design, build and test the Relativity Mission, as well as the detailed understanding of the requirements for the Dewar and spacecraft, resides at Stanford University in Palo Alto, CA. Science experiment hardware development (probe, gyros, Dewar, etc.) and spacecraft development are conducted at Stanford in collaboration with Lockheed Martin Missiles and Space Palo Alto Research Laboratory (LPARL). Lockheed Martin Missiles and Space is performing spacecraft development and systems integration.

SCHEDULE & OUTPUTS

Payload Flight Verification Plan: February 1999 Revised: July 2000 Revised: September 2001	Complete payload (dewar, science instrument, and probe) testing and verification. Schedule delay was driven by the need to repair the probe after failures during verification testing, by added system test content and by the need to repeat testing and verification.
Spacecraft Design, Fab, Assy, and Test Plan: March 1999 Revised: June 2000 Revised: August 2001	Complete the spacecraft design, fabrication, assembly, and test. Work has been deliberately slowed to allow more resources to be applied to the payload.
Flight Vehicle Integration and Test Plan: FY 2002	Initiate flight vehicle integration and test (I&T).
Final integration and test Plan: March 2000 Revised: September 2000 Revised: July 2001 Revised: August 2002	Complete final integration and test of the Gravity Probe-B science payload with the spacecraft.
Launch Plan: March 2000 Revised: October 2000 Revised: September 2001 Revised: October 2002	Successful launch and checkout. Launch has been delayed due to development problems cited above and to enable additional system testing.

ACCOMPLISHMENTS AND PLANS

Gravity Probe-B was proceeding toward a September 2001 launch date until a failure in the flight probe, discovered during payload flight verification, eliminated that possibility in the fall of 1999. De-integration of the payload and the implementation of design modifications were required, resulting in the program being re-baselined in March 2000 to a May 2002 launch. At the time of the rebaselining, the program was directed by the Agency Program Management Council to establish a set of critical milestones, which would be tracked by senior Agency management.

We are carefully and continuously monitoring all of the critical milestones, as well as the cost trends on this program. Should the program miss any of these milestones or should cost trends become unfavorable, NASA will initiate a termination review for Gravity Probe-B.

Accomplishments in FY 2000 included hardware rework. All eight of the FY 2000 critical milestones were completed on time.

The probe and Dewar were successfully re-integrated in October 2000. The decision to add additional test content (payload acoustic, sub-atmospheric refill trial and endgame gyro testing) resulted in the program being re-baselined again in November 2000 and Gravity Probe-B is now proceeding toward an October 2002 launch. The spacecraft is manifested to launch aboard a Delta II. In FY 2001, the program expects to complete the payload electronics and all integrated payload testing, with delivery of the payload to the spacecraft contractor by October 1, 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

THERMOSPHERE, IONOSPHERE, MESOSPHERE ENERGETICS AND DYNAMICS (TIMED)

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
TIMED Development *	27,500	13,280	

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The primary objective of the TIMED mission is to investigate the energetics of the Mesosphere and Lower Thermosphere/Ionosphere (MLTI) region of the Earth's atmosphere (60-180 km altitude). The MLTI is a region of transition in which many important processes change dramatically. It is a region where energetic solar radiation is absorbed, energy input from the aurora maximizes, intense electrical currents flow, and atmospheric waves and tides occur; and yet, this region has never been the subject of a comprehensive, long-term, global investigation. TIMED will provide, for the first time, a core subset of measurements defining the basic states (density, pressure, temperature, winds) of the MLTI region and its thermal balance. These measurements will be important for developing an understanding of the basic processes involved in the energy distribution of this region and the impact of natural and anthropogenic variations. In a society increasingly dependent upon satellite technology and communications, it is vital to understand atmospheric variability so that the impact of these changes on tracking, spacecraft lifetimes, degradation of materials, and re-entry of piloted vehicles can be predicted. The mesosphere may also show evidence of anthropogenic effects that could herald global-scale environmental changes. TIMED will characterize this region to establish a baseline for future investigations of global change.

STRATEGY FOR ACHIEVING GOALS

The TIMED mission is the first science mission in the program of Solar Terrestrial Probes (STP). TIMED is being developed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL). The Aerospace Corporation, the University of Michigan, NASA's Langley Research Center with the Utah State University's Space Dynamics Laboratory, and the University of Colorado will provide instruments for the TIMED mission.

The program began its Phase C/D development period in April 1997. TIMED will be a single spacecraft located in a high-inclination, low-Earth orbit with instrumentation to remotely sense the mesosphere/lower thermosphere/ionosphere regions of the Earth's atmosphere. TIMED will carry four instruments: the Solar Extreme ultraviolet Experiment (SEE), the Sounding of Atmospheric using Broadband Emission Radiometry (SABER) infrared sounder, the Global Ultraviolet Imager (GUVI) and the TIMED Doppler Interferometer (TIDI).

SCHEDULE & OUTPUTS

Launch Plan: 1st Qtr FY 2001 Revised: 4th Qtr FY 2001	TIMED will be delivered on time for launch aboard a Delta II launch vehicle co-manifested with JASON, an Earth Science mission, and will be completed within 10% of the planned development budget. TIMED was ready for launch in May 2000. However, due to Jason's inability to meet the May launch date, the launch is now scheduled for summer 2001. The planned development budget has been exceeded by more than 10% as a result of the Jason launch delay.

ACCOMPLISHMENTS AND PLANS

TIMED was ready for launch in May 2000 aboard a Delta II launch vehicle, co-manifested with Jason, an Earth Science mission. However, due to Jason's inability to meet the May launch date, the launch is now scheduled for summer 2001. TIMED will be delivered to support whatever launch readiness date is established for the Jason payload.

BASIS OF FY 2002 FUNDING REQUIREMENT

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Stratospheric Observatory for Infrared Astronomy	42,000	38,914	37,000

PROGRAM GOALS

The primary objective of the SOFIA program is to make fundamental scientific discoveries and contribute to our understanding of the universe through gathering and rigorous analysis and distribution of unique infrared astrophysical data. This objective will be accomplished by extending the range of astrophysical observations significantly beyond that of previous infrared airborne observatories through increases in sensitivity and resolution.

While accomplishing its scientific mission, the SOFIA program will make significant and measurable contributions to meeting national goals for the reform of science, mathematics, and technology education, particularly at the K-12 level, and to the general elevation of scientific and technological literacy throughout the country. In addition, the SOFIA program will identify, develop, and infuse promising new technologies, which will enable or enhance scientific or educational objectives and reduce mission life-cycle costs.

STRATEGY FOR ACHIEVING GOALS

Astronomical research with instrumented jet aircraft has been an integral part of the NASA Physics and Astronomy program since 1965. For relatively low cost, NASA airborne systems have been able to provide to the science community very quick, global response to astronomical "targets of opportunity." SOFIA consists of a 2.5 m telescope, provided by the German Aerospace Center (DLR), integrated into a modified Boeing 747 aircraft. With spatial resolution and sensitivity far superior to the Kuiper Airborne Observatory (KAO) which it is replacing, SOFIA will facilitate significant advances in the study of a wide variety of astronomical objects. SOFIA is expected to operate for at least 20 years. The program will build upon a very successful program of flying teachers on the KAO, by using SOFIA to reach out to K-12 teachers as well as science museums and planetaria around the country.

Development of SOFIA started in FY 1997. In December 1996, NASA selected a team led by the Universities Space Research Association (USRA), Columbia, MD to acquire, develop and operate SOFIA. The contract is managed by NASA's Ames Research Center, Mountain View, CA. Other team members include Raytheon Systems Company, Waco, TX; United Airlines, San Francisco; an alliance of the Astronomical Society of the Pacific and The SETI Institute, both of Mountain View, CA; Sterling Software, Redwood City, CA; and the University of California at Berkeley and Los Angeles.

SCHEDULE & OUTPUTS

Telescope Assembly Critical Design Review Plan: November 1998 Revised: April 2000 Actual: April 2000	Formal review of the German contractor's concept for implementation of the telescope assembly. Slipped due to delays in the development of the German telescope assembly. Successfully completed in April 2000.
US System Critical Design Review Plan: September 1999 Revised: June 2000 Actual: June 2000	Formal review of the US concept for implementation of the observatory. Slipped due to delays in the development of the German telescope assembly . Successfully completed in June 2000.
Complete the 747 Section 46 Mockup Test Activity Plan: June 2000 Revised: 2nd Qtr FY 2001 Actual: 2nd Qtr FY 2001	Subject to replanning activities, it is anticipated that the U.S. systems CDR will be completed, the fuselage section mockup pathfinder work will be completed, and major aspects of the structural modification of the 747 SP will be underway. Successfully completed in 2nd Qtr. FY 2001.
Complete Forward Pressure Bulkhead Installation Plan: FY 2002	Complete installation of the forward pressure bulkhead.
Install Cavity Door on Fuselage Mockup Plan: 1st Qtr FY 2001 Revised: Under Review	Complete the installation of the flight cavity door on the 747 SP fuselage mockup, with no anomalies that would require redesign. Cost growth has forced a replanning of the SOFIA program schedule, which is ongoing as of March 2001. This activity will be delayed.
Complete 747 Structural Modification Plan: FY 2001 Revised: Under Review	Complete structural modification of the 747 SP. Cost growth has forced a replanning of the SOFIA program schedule, which is ongoing as of March 2001. This activity will be delayed.

ACCOMPLISHMENTS AND PLANS

In FY 2000, the German Telescope Assembly and U.S. systems critical design reviews (CDRs) were completed, and major aspects of the structural modification of the 747 SP began. Our German partners are also far along in the fabrication and test of all major elements of the Telescope Assembly.

Cost growth, first identified in late 2000, has forced a replanning of the SOFIA schedule, which is ongoing as of March 2001. The Ames Research Center is seeking to minimize the schedule impact and cost growth by all possible means.

BASIS OF FY 2002 FUNDING REQUIREMENT

SOLAR TERRESTRIAL RELATIONS OBSERVATORY (STEREO)

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Solar Terrestrial Relations Observatory (STEREO).............	[8,300]	[21,900]	50,300

PROGRAM GOALS

The primary objective of the STEREO mission is to understand the origin and consequences of coronal mass ejections (CMEs). CMEs are the most energetic eruptions on the Sun. They are responsible for essentially all of the largest solar energetic particle events and are the primary cause of major magnetic storms at Earth. STEREO will, for the first time, unveil the Sun in three dimensions. This will be achieved by sending two identically instrumented spacecraft, both in 1 Astronomical Unit orbits around the Sun, but one flying well ahead of the Earth and one behind. The instrument suite for STEREO will measure physical characteristics of CMEs with remote sensing and local sensing instruments, allowing scientists to determine solar origins of CMEs, their propagation into the interplanetary medium and ultimately their travel to Earth (for events directed toward Earth). By viewing CMEs in three dimensions, STEREO will be able to pinpoint their speed and distance from Earth, and thus more accurately time the arrival of the plasma cloud.

STRATEGY FOR ACHIEVING GOALS

The STEREO mission is the third mission in a planned program of Solar Terrestrial Probes (STP), as detailed in the Space Science Strategic Plan. STEREO's anticipated launch date is December 2004. The planned 2004 launch date will enable STEREO to make observations during the simpler, declining phase of the current activity cycle, which reached solar maximum in early 2001. The Johns Hopkins University Applied Physics Laboratory is responsible for developing the STEREO spacecraft, with instruments being provided by a number of U.S. and international science teams.

SCHEDULES & OUTPUTS

Development Contracts Plan: FY 2002	Have contracts in place for start of spacecraft and instrument detailed design and fabrication.

ACCOMPLISHMENTS AND PLANS

STEREO completed the System Requirements Review (SRR) and instrument selection in FY 2000. Phase A studies were completed in early FY 2001 and Phase B studies were started. THE STEREO confirmation review is planned for early FY 2002, marking the transition from formulation into implementation. After approval to proceed into implementation, STEREO will begin spacecraft and instrument detailed design and fabrication in FY 2002.

BASIS OF FY 2002 FUNDING REQUIREMENT

GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST)

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Gamma-Ray Large Area Space Telescope (GLAST)	[4,900]	[4,700]	19,400

PROGRAM GOALS

The primary objective of the GLAST mission is to understand the most powerful energy sources in the universe. The Universe in which we live is home to numerous exotic and beautiful phenomena, some of which can generate an almost inconceivable amount of energy. Because of their tremendous energy, gamma-rays travel through the Universe largely unobstructed. This means GLAST will be able to observe sources of gamma-rays near the edge of the visible Universe. GLAST will observe exotic objects like supermassive black holes, pulsars, and gamma-ray bursts, but will also probe the star formation history of the Universe and explore the physics of dark matter. Exploring these high-energy objects and events with the advanced technologies of GLAST could give us an entirely new understanding of our Universe and reveal unanticipated phenomena, particularly in fundamental physics.

STRATEGY FOR ACHIEVING GOALS

Because of their high energies, gamma-rays cannot be focused by a lens mirror like visible light in an optical telescope. The gamma-rays would pass, unaffected, directly through any such telescope. A gamma-ray telescope, therefore, makes use of detectors instead. GLAST will be equipped with two instruments for gamma-ray detection. These instruments, recently selected through peer-reviewed competition, are the Large Area Telescope (LAT) and the GLAST Burst Monitor (GBM). The LAT is the primary instrument for GLAST and is a next-generation gamma-ray telescope. The primary characteristics that distinguish the GLAST LAT from its predecessor are its wide field of view, greatly improved sensitivity (especially at the highest energies), superior positional accuracy, and timing accuracy free from electronic "dead-time" effects. The LAT's detectors also do not depend on any expendable materials, so the instrument can have a long lifetime in orbit. The GBM is the secondary instrument aboard GLAST and is composed of two sets of detectors that will be used to aid in the study of gamma-ray bursts.

GLAST involves the cooperative efforts of the US Department of Energy as well as institutions in France, Germany, Japan, Italy and Sweden. Launch is planned for 2007 on a Delta-II rocket. A five-year mission life is assumed (goal of 10 years) with the first year dedicated to an all-sky survey followed by pointed observations.

SCHEDULES & OUTPUTS

GLAST Technology Development Plan: FY 2002	Conduct Large Area Telescope Preliminary Design Review (PDR).

ACCOMPLISHMENTS AND PLANS

GLAST will continue in formulation during FY 2001 with implementation planned for early FY 2002.

BASIS OF FY 2002 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Rosetta	6,950	7,284	1,300
Cluster-II	1,000	--	--
Solar-B	--	15,865	21,900
Spartan	500	499	500
Herschel	[16,100]	[15,500]	14,600
Other Shuttle/International payloads	6,000	9,778	6,500
Total	14,450	33,426	44,800

PROGRAM GOALS

Payload and Instrument Development supports the development of hardware to be used on international satellites or on Shuttle missions. International collaborative programs offer opportunities to leverage U.S. investments, and thus to obtain scientific data at a relatively low cost. Shuttle missions utilize the unique capabilities of the Shuttle to perform scientific experiments that do not require the extended operations provided by free-flying spacecraft.

STRATEGY FOR ACHIEVING GOALS

The European Space Agency's Rosetta mission is a mission to a comet. The satellite will rendezvous with comet Wirtanen in late 2011, and orbit it while taking scientific measurements. During the cruise phase, the satellite will be given gravity assist maneuvers once by Mars (2005) and twice by the Earth (2005 and 2007). The satellite will also take measurements during fly-bys of two asteroids. U.S involvement in the Rosetta program includes the development of three remote sensing instruments, a subsystem for a fourth instrument, as well as support for an interdisciplinary scientist and a number of U.S. co-investigators.

The original Cluster mission, part of the International Solar-Terrestrial Physics program, was lost on June 4, 1996 with the explosion of its Ariane-5 launch vehicle. ESA and NASA approved reflight of the full mission (Cluster-II). The four spacecraft were successfully launched in the summer of 2000, and are carrying out three-dimensional measurements in the Earth's magnetosphere, covering both large- and small-scale phenomena in the sunward and tail regions.

Solar-B is an international cooperative mission between NASA, the Particle Physics and Astronomy Research Council (PPARC) of the United Kingdom, and the Institute of Space and Astronautical Science (ISAS) of Japan, which is leading the mission. Solar-B is the second mission in the Solar Terrestrial Probes (STP) Program and is a follow-on to the successful Solar A (or Yohkoh) mission. It will perform coordinated, simultaneous measurements of the different layers of the solar atmosphere from a Sun-synchronous orbit around the Earth. The data will be used to improve our understanding of the mechanisms that give rise to solar magnetic variability and how this variability modulates the total solar output and creates the driving force behind space weather. The U.S. Solar-B project provides optical, extreme ultraviolet, and x-ray instrument components to measure the Sun's magnetic field and UV/X-ray radiation. ISAS provides the spacecraft and launch vehicle and major elements of each of the scientific instruments. Solar-B's expected launch date is FY 2005.

The Spartan program provides reusable spacecraft, which can be flown aboard the Shuttle. These units can be adapted to support a variety of science payloads and are deployed from the Shuttle cargo bay to conduct experiments for a short time (i.e. several hours or days). Payloads are later retrieved, reinstalled into the cargo bay and returned to Earth. The science payload is returned to the mission scientists for data retrieval and possible refurbishment for a future flight opportunity. The Spartan carrier is also refurbished and modified as needed to accommodate the next science payload.

The Herschel Observatory (formerly called Far Infrared and Submillimetre Telescope or FIRST) is a cornerstone mission of ESA and will help to solve the mystery of how stars and galaxies were born. It will be launched on an Ariane-5 rocket together with Planck in 2007. NASA's contributions to Herschel include major components of two of the three instruments: the Spectral and Photometric Imaging Receiver (SPIRE) and the Heterodyne Instrument for FIRST (HIFI). Herschel has a minimum operational lifetime of three years and potentially offers about 7000 hours of science time per year.

Planck is the third Medium-Sized Mission (M3) of ESA's Horizon 2000 Scientific Program. It is designed to image the anisotropies of the Cosmic Background Radiation Field over the whole sky, with unprecedented sensitivity and angular resolution. Planck will help resolve several cosmological and astrophysical issues by verifying or refuting the assumptions underlying competing theories of the early universe and the origin of cosmic structure. Planck is expected to be launched with the Herschel satellite but will separate and be placed in a different orbit around the second Lagrangian point of the Earth-Sun System. Although formal agreements have not been finalized, NASA expects to contribute hardware elements for the mission in exchange for science participation.

The Shuttle/International Payloads program also funds U.S. development projects supporting Europe's International Gamma Ray Astrophysics Laboratory (INTEGRAL). The ESA INTEGRAL mission will perform detailed follow-on spectroscopic and imaging studies of objects initially explored by the Compton Gamma Ray Observatory. Its enhanced spectral resolution and spatial resolution in the nuclear line region will provide a unique channel for the investigation of processes -- nuclear transitions, electron/positron annihilation, and cyclotron emission/absorption -- taking place under extreme conditions of density, temperature, and magnetic field. U.S. participation consists of co-investigators providing hardware and software components to the spectrometer and imager instruments; a co-investigator for the data center; a mission scientist; and a provision for ground tracking and data collection.

SCHEDULE & OUTPUTS

Rosetta:

Qualification Model Deliveries Plan: May 2000 Actual: May 2000	Deliver the electrical qualification models for the four U.S.-provided instruments to ESA in May 2000 for integration with the Rosetta Orbiter. All electrical models/electrical qualification models were delivered in (or before) May 2000.
Flight Unit Deliveries Plan: 3rd Qtr FY 2001	Deliver the flight units for the four U.S.-provided instruments or instrument subsystems to ESA.

Cluster-II:

Instrument Analysis Software and Verification Plan: FY 2000 Actual: FY 2000	Complete the development of the Cluster-II instrument analysis software for the one U.S. and five U.S.-partnered instruments before launch and, if launch occurs in FY00, activate and verify the wideband data and U.S. subcomponents after launch. Software development was completed. The four spacecraft were launched in pairs on July 15, 2000 and August 9, 2000. All instruments have been activated on each of the spacecraft and their science data has been captured, analyzed, and verified.

Solar-B:

Pre-Environmental Review Plan: FY 2002	Conduct the Pre-Environmental Review for the U.S.-provided Extreme Ultraviolet Imaging Spectrometer (EIS).

Other Shuttle/International:

INTEGRAL Operations Readiness Plan: FY 2000 Actual: FY 2000	Prepare the INTEGRAL Science Data Center (ISDC) for data archiving and prepare instrument analysis software for the Spectrometer on INTEGRAL (SPI) instrument. Achieved through the use of two veteran software teams. The ISDC software has been completed, as have both portions of the SPI software, at a total cost 3.9% below the estimate.)
Planck Cooler Test Plan: April 2000 Revised: FY 2001	Assemble and successfully test the breadboard cooler for ESA's Planck mission. This milestone was not consistent with the phasing of program funding. Expect target to be completed in FY 2001.

Planck Cooler Performance Report Plan: 4th Qtr FY 2001	Deliver the Preliminary Breadboard Cooler Performance Report.
Planck HFI Flight Detectors Plan: FY 2002	Complete the High-Frequency Instrument (HFI) flight detectors.

ACCOMPLISHMENTS AND PLANS

All US-provided Rosetta engineering qualification and electronic models were delivered in FY 2000, and the US Rosetta flight instruments will be delivered to ESA by the 3rd quarter of FY 2001.

The four Cluster-II spacecraft were successfully launched in the summer of 2000, and are carrying out three-dimensional measurements in the Earth's magnetosphere, covering both large- and small-scale phenomena in the sunward and tail regions.

Solar-B completed PDR in May 2000. Shortly after PDR, ISAS announced a one-year slip in the launch date from August 2004 to September 2005. This resulted in Phase B being extended through December 2000 and a new schedule baseline. Solar-B received approval to proceed into implementation in December 2000 after the November Confirmation Review. Engineering models will be delivered in late FY 2001. Pre-environmental reviews will start in FY 2002.

Spartan continues as an advanced carrier, which could support Explorer missions, environmental science initiatives, as well as Space Station free-flyers.

INTEGRAL’s pulse shape discriminator (PSD) and the instrument data analysis software simulator for the Integral Spectrometer (SPI) were successfully delivered to CNES during FY 2000. The spectroscopic data analysis software for science data analysis was also delivered to the Integral Science Data Center (ISDC). Monte Carlo simulations of the background and source response of the SPI for science data analysis will be performed during FY 2001, as will software checkout.

Herschel’s Confirmation Review is planned for the third quarter of FY 2001 and instrument fabrication will begin in FY 2002.

During FY 2000, PLANCK completed the formulation and preliminary design phase, resulting in a successful project Preliminary Design Review and Confirmation Readiness Review. In FY 2001 PLANCK will complete its Confirmation Review and begin implementation and detailed design.

BASIS OF FY 2002 FUNDING REQUIREMENT

EXPLORER PROGRAM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Imager for Magnetopause-to-Aurora Global Exploration........	6,400	--	--
Microwave Anisotropy Probe......................	28,000	18,492	--
Swift Gamma Ray Burst.......................	22,200	49,050	47,400
Full-sky Astrometric Mapping.....................	5,200	19,954	61,700
Small Explorer (SMEX) Program	48,800	37,023	8,400
Explorer Planning (All Others).....................	11,900	16,769	37,500
*Total	122,500	141,288	155,000

*Total cost information is provided in the Special Issues section.

PROGRAM GOALS

The goal of the Explorer Program is to accomplish frequent, high-quality space science investigations utilizing innovative, streamlined, and efficient management approaches. The program seeks to substantially reduce mission cost through commitment to, and control of, design, development, and operations costs, as well as to reduce cost and improve performance through the use of new technology. Finally, Explorers seek to enhance public awareness of, and appreciation for, space science and to incorporate educational and public outreach activities as integral parts of space science investigations. Investigations selected for Explorer projects are usually of a survey nature, or have specific objectives not requiring the capabilities of a major observatory.

STRATEGY FOR ACHIEVING GOALS

Explorer mission development is managed within an essentially level funding profile. New mission starts are, therefore, subject to the availability of sufficient funding in order to stay within the total program budget. Explorer missions are categorized by size, starting with the largest, the Medium-class (MIDEX) missions launched by Delta Expendable Launch Vehicles (ELVs), and moving down through the Small-class (SMEX) missions launched on Pegasus-class ELVs and the University-class (UNEX) missions generally co-manifested with larger payloads on a variety of launchers. Funding for launch services and mission studies is included within the Explorer budget. The Explorer Program Office at the Goddard Space Flight Center (GSFC) manages mission definition, development, and launch of these missions. For further information on the Explorer missions, visit the website at http://explorers.gsfc.nasa.gov/index.html.

Medium Class

The Medium-class Explorer (MIDEX) program was initiated to facilitate more frequent flights, and thus more research opportunities, in all OSS themes. The MIDEX investigations are characterized by definition, development, launch service, and mission operations and data analysis cost not to exceed $170 million (in Fiscal Year 2002 dollars) total cost to NASA. NASA's goal is to launch one MIDEX mission per year.

In March 1996 NASA selected the first two science missions for the MIDEX program, the Microwave Anisotropy Probe (MAP) and the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE). The MAP Mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos. GSFC is developing the MAP instruments in cooperation with Princeton University. The IMAGE mission uses three-dimensional imaging techniques to study the global response of the Earth's magnetosphere to variations in the solar wind, the stream of electrified particles flowing out from the Sun. The magnetosphere is the region surrounding the Earth, controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. Southwest Research Institute developed the IMAGE mission, which launched in March 2000.

In October 1999, NASA selected MIDEX 3 & 4, the Swift Gamma Ray Burst Explorer (Swift) and Full-sky Astrometric Mapping Explorer (FAME) missions. Swift is a three-telescope space observatory for studying gamma ray bursts. Dr. Neil Gehrels of NASA's Goddard Space Flight Center will lead the Swift mission. FAME is a space telescope designed to obtain highly precise position and brightness measurements of 40 million stars. Dr. Kenneth J. Johnston of the U.S. Naval Observatory will lead the FAME mission.

An Announcement of Opportunity for MIDEX 5 & 6 is planned for release in the summer of 2001. A Step-1 selection is planned for early CY 2002, followed by a Step-2 selection in the fall of 2002.

Small Class

The Small Explorer (SMEX) program provides frequent flight opportunities for highly focused and relatively inexpensive missions. SMEX investigations are characterized by a total cost to NASA for definition, development, launch service, and mission operations and data analysis not to exceed $85 million (in Fiscal Year 2002 dollars). It is NASA's goal to launch one Small Explorer mission per year.

The High Energy Solar Spectroscopic Imager (HESSI) and the Galaxy Evolution Explorer (GALEX) missions were selected in October 1997. HESSI will observe the Sun to study particle acceleration and energy release in solar flares. The Galaxy Evolution Explorer (GALEX) is an Ultraviolet Small Explorer mission that will map the global history of the universe through 80 percent of its life. GALEX will probe the causes of star formation during that period in which galaxies evolved dramatically, and most stars, elements, and galaxy disks had their origins. HESSI is being developed by the University of California at Berkeley. The GALEX mission is being developed by the California Institute of Technology.

An Announcement of Opportunity for the next two SMEX missions was released in December 1999. Seven SMEX proposals and one Mission of Opportunity proposal were selected in September 2000 for concept studies, and one Mission of Opportunity proposal was selected for flight. The eight missions selected for study will begin a six-month concept study not later than October 2001. After a thorough evaluation of the results of Phase A studies has been completed, NASA expects to select two SMEX missions for launch in 2004 and 2005. NASA may or may not select the Mission of Opportunity for flight.

Student Explorer Demonstration Initiative and University Class

The University-class Explorer (UNEX) program was initiated to enable a higher flight rate to provide the academic community with routine access to space science research. The UNEX program supports very small, low-cost missions managed, designed and developed at universities, in cooperation with industry. The program has sought to develop greater technical expertise within the academic community beyond the suborbital class missions currently being flown aboard balloons and sounding rockets, thus creating greater opportunity for students and reducing the required role of NASA in-house expertise.

From responses to a UNEX AO released in January 1998, NASA selected Cosmic Hot Interstellar Plasma Spectrometer (CHIPS) and IMEX. CHIPS will use an extreme ultraviolet spectrograph during its one-year mission to study the “Local Bubble,” a tenuous cloud of hot gas surrounding our solar system that extends about 300 light-years from the Sun. CHIPS will be developed by the University of California Berkeley. SpaceDev will build the CHIPS spacecraft. IMEX was to have entered Phase B in FY 2001. However, in January 2001the project was not confirmed for preliminary design due to cost growth.

The UNEX precursor missions under the Student Explorer Demonstration Initiative (STEDI) included the Cooperative Astrophysics and Technology Satellite (CATSAT). CATSAT is being developed by the University of New Hampshire with launch planned in 2002.

MISSIONS OF OPPORTUNITY

Missions of Opportunity (MO) were instituted within the Explorer Program as part of the previously mentioned SMEX AO. MO are space science investigations, costing no more than $35 million in FY 2002 dollars, that are flown as part of a non-NASA space mission. MO is conducted on a no-exchange-of-funds basis with the organization sponsoring the mission. OSS intends to solicit proposals for MO with all future Explorer AOs.

HETE-II, an international (France, Italy and Japan) collaboration, was launched in October 2000 from Kwajalein Island. HETE-II will obtain precise positions of gamma-ray bursters and other high-energy transient sources. HETE-II is a replacement for HETE-I, which was lost in November 1996 due to launch vehicle third-stage power failures.

Under the 1997 SMEX AO, the Two Wide-Angle Neutral-Atom Spectrometers (TWINS) investigation was selected as a MO. TWINS will enable three-dimensional global visualization of Earth’s magnetospheric region, thereby greatly enhancing understanding of the connections between different regions of the magnetosphere and their relation to the solar wind. Los Alamos National Laboratory (LANL) is developing instruments for the TWINS mission.

Under the 1999 SMEX AO, the Coupled Ion-Neutral Dynamics Investigations (CINDI) were selected as a MO. CINDI will provide two instruments for the Air Force's Communications/Navigation Outage Forecast System (C/NOFS) satellite that will lead to a better understanding of the dynamics of the Earth's ionosphere.

SCHEDULE & OUTPUTS

Medium-class Explorer Program

IMAGE	
Delivery, Launch	IMAGE will be delivered for an on-time launch.
Plan: February 2000	
Actual:	IMAGE launched successfully on March 25, 2000. IMAGE was delivered early (in September).
Delivered September 1999	Note: Red Team review and industry-wide electronic part (Interpoint converter) alert caused a six-
Launched March 2000	week launch delay.
MAP	
Begin Environmental Testing	Begin system-level environmental testing of the spacecraft.
Plan: July 2000	
Actual: September 2000	Testing began in September 2000, a slight delay due to technical problems with electronic parts (Interpoint converters). Industry-wide alert led to change-out.
Delivery, Launch	Deliver MAP for launch.
Plan: 1st Qtr FY 2001	Delayed primarily due to difficulties in completing thermal blanketing during spacecraft
Revised: 3rd Qtr FY 2001	integration.
Swift	
Spacecraft Subsystems	Complete build-up of spacecraft subsystems.
Plan: FY 2002	
FAME	
Confirmation Review	Conduct Confirmation Review (CR).
Plan: FY 2002	

Small-class Explorer Program

<u>HESSI</u>

Delivery, Launch Plan: July 2000 Actual/Revised: Delivery: January 2001 Launch: 3rd Qtr FY 2001	HESSI will be delivered in time for a planned July 2000 launch. Spacecraft damaged during system vibration test. Shipment for launch occurred in January 2001.

<u>GALEX</u>

Instrument Delivery Plan: July 2000 Revised: 4th Qtr. FY 2001	Deliver the GALEX science instrument from JPL to the Space Astrophysics Laboratory at Caltech during April 2000 for science calibration. The instrument will be fully integrated, functionally tested, and environmentally qualified at the time of the delivery. Problems in detector development and telescope fabrication, coupled with delays in electronics development due to loss of key manpower resulted in the slip of this milestone. Will ship in late FY01.
Delivery, Launch Plan: 4th Qtr., FY 2001 Revised: FY 2002	Deliver GALEX for launch. Slipped due to the instrument problems cited above.

<u>TWINS</u>

Component Deliveries Plan: March 2000 Revised: 3rd Qtr., FY 2001	Deliver to the Los Alamos National Laboratory, in March 2000, all components for system integration and testing of the first flight system for the TWINS mission. The TWINS mission is a payload of opportunity. All components were ready for acceptance as required. However, as requested, delivery has been delayed to accommodate the schedule of the non-NASA host spacecraft. Accordingly, delivery of the first flight model components, including the electronics box, is scheduled to occur by mid-FY01.
Complete Flight Model #1 Plan: FY 2002	Complete work on flight model #1 to be ready for delivery.

University-class Explorer Program

CATSAT	
Launch	Deliver the CATSAT for launch.
Plan: 4th Qtr FY 2001	
Revised: FY 2002	Delayed due to uncertain launch accommodations and issues with launch partner, ICESAT.

HETE-II	
Launch	Complete HETE-II development and launch spacecraft.
Plan: December 1999 Revised: January 2000 Actual: October 2000	HETE –II was launched on October 9, 2000. Launch delay was due to: delays in gaining the approval required for launches from Kwajalein Island; the addition of Red Team Review; and the temporary grounding of all NASA Pegasus ELVs, which has since been lifted.

AO Activities

SMEX AO Selection	Mission selection, leading to concept studies.
Plan: 1st Qtr FY 2000	
Revised: 4th Qtr. FY 2000	Seven SMEX missions were selected for concept studies.
Actual: 4th Qtr. FY 2000	
SMEX Selection	Down-selection (Step 2) for SMEX 8 and SMEX 9.
Plan: FY 2001	
Revised: FY 2002	Due to budget constraints, the down-selection of two missions for flight has been delayed until FY 2002.

ACCOMPLISHMENTS AND PLANS

The Explorers Program launched one mission during FY 2000: IMAGE successfully launched from Vandenberg AFB on March 25, 2000. Spacecraft and instrument development for the MAP, HESSI and GALEX missions continued throughout FY 2000, although HESSI suffered a setback in March when it sustained substantial damage during vibration testing. The spacecraft's structure was damaged and two of the four solar arrays were cracked. TWINS held a successful critical design review in February 2000 and development is proceeding with no problem. Formulation for Swift, FAME and CHIPS continued. However, the decision not to proceed with IMEX beyond the extended Phase A study was made in January 2001 due to growth in cost estimates. In September 2000, seven SMEX proposals and one Mission of Opportunity proposal were selected for concept studies and one Mission of Opportunity proposal was selected for flight.

Three missions are targeted for launch in fiscal year 2001: HETE-II, which was launched in October 2000; HESSI in spring 2001; and MAP in summer 2001. Both CHIPS and SWIFT completed formulation and were confirmed for implementation in December 2000 and February 2001, respectively. Delivery of the TWINS first flight model, including electronics box, to the Los Alamos National Laboratory is scheduled to occur by mid-FY 2001. The GALEX science instrument will be shipped in late FY 2001 from JPL to the Space Astrophysics Laboratory at Caltech for science calibration. The instrument will be fully integrated, functionally tested and environmentally qualified at the time of delivery. CINDI will begin its concept study in FY 2001, which, after review, will be followed by definition, a confirmation review and implementation.

During preparation of the FY 2002 budget, NASA determined that the Space Science UNEX program was not producing sufficient scientific return on the Agency's investment. The student training opportunities on UNEX missions have also been deemed to be too limited. As a result, NASA is deferring selection of any new UNEX missions indefinitely.

Three Explorer missions are planned to launch in FY 2002: GALEX, CATSAT, and CHIPS. Swift plans to complete build-up of the spacecraft subsystems in FY 2002 and FAME will go through its Confirmation Review. TWINS expects to complete work on flight model #1 and CINDI will continue formulation. It is expected that two SMEX missions will be down-selected for flight, and potentially a Mission of Opportunity, during FY 2002.

BASIS OF FY 2002 FUNDING REQUIREMENT

DISCOVERY PROGRAM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Genesis *	62,300	25,486	--
CONTOUR *	52,100	53,881	26,500
MESSENGER	--	31,730	97,400
Deep Impact	--	57,174	84,200
Future Missions	35,900	44,702	9,000
Total	150,300	212,973	217,100

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The Discovery program provides frequent access to space for small planetary missions that will perform high-quality scientific investigations. The program responds to the need for low-cost planetary missions with short development schedules. Emphasis is placed on increased management of the missions by principal investigators. Missions are selected through open, peer-reviewed competitions, to ensure science community involvement while enhancing the U.S. return on its investment. The Discovery program also aids in the national goal to transfer technology to the private sector. The cost of building, launching, and operating a Discovery mission must not exceed $300 million in FY 2001 dollars, and the mission must launch within three years from start of development.

STRATEGY FOR ACHIEVING GOALS

The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis. Genesis will return samples of isotopes of oxygen, nitrogen, the noble gases, and other elements to an airborne capture in the Utah desert. Such data are crucial for improving theories about the origin of the Sun and the planets, which formed from the same primordial dust cloud. The mission is led by Dr. Donald Burnett from the California Institute of Technology, Pasadena, CA. JPL will provide the payload and project management, while Lockheed Martin Astronautics of Denver, CO will provide the spacecraft.

The Comet Nucleus Tour (CONTOUR) mission is intended to dramatically improve our knowledge of key characteristics of comet nuclei and to assess their diversity. The spacecraft will leave Earth orbit, but stay relatively near Earth while intercepting at least three comets. The targets span the range from a very evolved comet (Encke) to a future “new” comet such as Hale-Bopp. CONTOUR builds on the exploratory results from the Halley flybys, and will extend the applicability of data obtained by NASA's Stardust and

ESA's Rosetta to broaden our understanding of comets. The Principal Investigator is J. Veverka of Cornell University; the Johns Hopkins University Applied Physics Laboratory (JHU/APL) of Laurel, MD provides the spacecraft and project management.

In July 1999, two new Discovery missions were selected, Deep Impact and MESSENGER, and in October 1999, the first Discovery Mission of Opportunity, ASPERA-3, was approved for implementation. Deep Impact is designed to fire a large (up to 500 kilogram) copper projectile into the comet P/Tempel 1, excavating a large crater more than 65 feet (20 meters) deep, in order to expose its pristine interior ice and rock. The impactor will be separated from the flyby spacecraft 24 hours prior to its impact on the surface of the comet. The impactor will have an active guidance system to steer it to impact on the sunlit side of the comet surface. The impactor will also relay close-up images of the comet's surface prior to impact back to the flyby spacecraft for downlink to Earth. Optical and infrared instruments on the flyby spacecraft will image and spectrally map the impact and resulting crater. The Deep Impact mission is led by Principal Investigator, Dr. Michael A'Hearn from the University of Maryland. Ball Aerospace & Technologies Corp. and JPL will develop the flight hardware and ground systems.

The Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER) mission will send an orbiter spacecraft carrying seven instruments to globally image and study the closest planet to the Sun. MESSENGER will be implemented by a consortium headed by the Principal Investigator, Dr. Sean Solomon of the Carnegie Institution of Washington. MESSENGER will be designed and built by JHU/APL, in collaboration with industrial partners GenCorp Aerojet (propulsion system) and Composite Optics, Inc. (integrated structure). JHU/APL, NASA/Goddard Space Flight Center, the University of Colorado, and the University of Michigan are supplying instruments and instrument subsystems. The Science Team is comprised of Co-Investigators from various institutions.

The Analyzer of Space Plasmas and Energetic Atoms (ASPERA-3) is a Discovery Mission of Opportunity that will provide parts of a scientific instrument to study the interaction between the solar wind and the atmosphere of Mars. It will fly aboard the European Space Agency's Mars Express spacecraft. The U.S. principal investigator being funded by NASA is Dr. David Winningham of the Southwest Research Institute, San Antonio, TX.

SCHEDULE & OUTPUTS

Genesis

Start Functional Testing Plan: November 1999 Actual: February 2000	Complete Genesis spacecraft assembly and start functional testing. Functional testing started on schedule in November 1999. However, a few spacecraft subsystems were delivered after this date, delaying completion of assembly. The work was fully completed as of February 2000. The slip was absorbed out of schedule reserves, with no impact to launch date.
Launch Plan: 2nd Qtr FY 2001 Revised: 3rd Qtr FY 2001	Deliver for launch. Genesis was initially scheduled to launch in January, 2001, but due to the need for JPL to concentrate their resources on the Mars Odyssey mission, and due to a conflict with the desired launch of the MAP Explorer mission, Genesis launch has been rescheduled for late July 2001.

CONTOUR

Preliminary Design Review Plan: 2nd Qtr FY 2000 Actual: 2nd Qtr FY 2000	Complete a PDR that confirms the design and maintains 15% margins for mass and power. PDR was successfully completed; margins were at or above 15%.
Complete Imager Breadboard Plan: September 2000 Actual: September 2000	Successfully complete the breadboard of the imager instrument for CONTOUR. Imager instrument breadboard successfully completed.
Propulsion System Contract Award Plan: FY 2000 Actual: FY 2000	Award the contract for the propulsion system following successful PDR. PDR was successful; propulsion system contract was awarded.
Critical Design Review Plan: FY 2001 Actual: December 2000	Successful CDR, meeting all program level requirements. CDR was successfully completed in December 2000.
<u>Environmental Testing</u> Plan: FY 2002	Complete environmental testing.

MESSENGER

Critical Design Review Plan: FY 2002	Conduct Critical Design Review (CDR).

Announcements of Opportunity (AOs)

AO Release Plan: FY 2000 Actual: FY 2000	Release an AO for the next Discovery mission. The AO was released on May 19, 2000.
Mission Selection Plan: FY 2001	We expect the next down-select to take place in late summer 2001.

ACCOMPLISHMENTS AND PLANS

During FY 1999, Genesis detailed design activities were completed, leading to the Critical Design Review in July 1999. System level integration and test activities will occur during FY 2000, with delivery to KSC in time for launch in July 2001.

The CONTOUR Preliminary Design Review and Confirmation Review were completed in January 2000. Development started in February 2000, leading to a Critical Design Review completed in December 2000.

MESSENGER and Deep Impact continued in the formulation phase through FY 2000, leading to planned Preliminary Design Reviews in FY 2001; in March for Deep Impact and August for MESSENGER, followed by confirmation reviews and the potential start of implementation.

A Discovery AO was released in May 2000 and three new missions, plus a contribution to a French-led Mars mission, were selected in January 2001 for further definition. Final selection(s) are expected in late FY 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

MARS EXPLORATION PROGRAM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
2001 Mars Odyssey*	109,200	38,316	--
2003 Mars Exploration Rovers (MER) *	18,900	302,000	207,000
Future Missions	120,700	87,248	223,900
[Construction of Facilities]	[--]	[5,000]	[7,000]
Total	248,800	427,564	430,900

*Total cost information is provided in the Special Issues section

PROGRAM GOALS

The newly reformulated Mars Exploration Program is pursuing four major goals and objectives:

1) To determine if **life** ever arose on Mars, and if it still exists today
2) To characterize Mars's ancient and present **climate** and climate processes
3) To determine the **geological processes** affecting the Martian interior, crust, and surface
4) To prepare for potential future **human exploration** of Mars, primarily through environmental characterization.

STRATEGY FOR ACHIEVING GOALS

The newly restructured Mars Exploration Program (MEP) will deliver a continuously refined view of Mars with the excitement of discovery at every step. The MEP strategy will respond to new science investigations that will emerge as discoveries are made. The strategy is linked to our exploration experience here on Earth, including experience in deep sea exploration and petroleum deposit searches, and uses Mars as a natural laboratory for understanding life and climate on Earth-like planets other than our own.

The basic scientific approach to achieving these goals is one of "Seek, In-Situ, and Sample". In the initial phases – and relying heavily on orbital instruments – the MEP will survey Mars to identify scientifically interesting areas in global context. Following this phase, more detailed measurements will be made by long-lived assets on the surface, allowing in-situ laboratory analyses to refine the interpretations developed during the previous orbital reconnaissance phase and confirm from the ground the observations made in orbit. Finally, samples of scientifically significant components of the Martian atmosphere, surface, and subsurface will be returned to Earth for definitive analytical investigation in ways that are not possible to be performed on the surface of Mars.

Mars Global Surveyor (MGS), the first of the MEP missions, is an orbiter that carries a science payload comprised of 5 of the original 8 spare Mars Observer instruments aboard a small, industry-developed spacecraft. MGS was launched successfully in November 1996 aboard a Delta II launch vehicle and has been producing highly valuable science output since it arrived at Mars in September 1997. The primary mapping mission concluded successfully on 31 January 2001. Among other discoveries, MGS images have provided potential evidence of recent liquid water flows at or near the surface of Mars.

The '98 Mars Orbiter and Lander consisted of the Mars Climate Orbiter (MCO) and the Mars Polar Lander (MPL). MCO launched in December 1998 and MPL launched in January 1999; however, both missions failed upon arrival at Mars.

One of the Mars 2001 Odyssey Orbiter's primary science objectives is to determine the elemental and chemical composition of the Martian surface. Odyssey will carry 3 science instruments, the Thermal Emission Imaging System (THEMIS), the Gamma Ray Spectrometer (GRS), and the Mars Radiation Environment Experiment (MARIE). THEMIS will map the mineralogy and morphology of the Martian surface using a high-resolution camera and a thermal infrared imaging spectrometer. The GRS will achieve global mapping of the elemental composition of the surface and determine the abundance of hydrogen in the shallow subsurface. The GRS is a rebuild of the instrument lost with the Mars Observer mission. The MARIE will characterize aspects of the near-space radiation environment as related to the radiation-related risk to human explorers. The 2001 Mars Odyssey Orbiter is scheduled for launch in April 2001, and will arrive at Mars in October 2001. Initial scientific data will be acquired starting in January 2002.

The twin 2003 Mars Exploration Rovers' (MERs) goal is to help determine whether water-related minerals exist at or near the Martian surface, and if so, whether they were produced by biological processes or some other mechanism. The MERs are twin robotic field geologists, which will provide the first microscopic study of rocks and soils on Mars. They may discover local evidence for how water once persisted at the surface and what ultimately to search for from orbit. The twin rovers will also have the mobility to travel up to 1000 meters across the Martian landscape, measuring the chemical character of the soils, rocks, and even the previously inaccessible interiors of rocks where unaltered materials may lurk. The MER robotic rovers will be built and operated by NASA's Jet Propulsion Laboratory, with launch currently are planned for May and June 2003. Both rovers will enter Mars' atmosphere and bounce to a stop on the Martian surface in January 2004.

The Future Mars Exploration budget includes the following items:

- Formulation activity (Phase A & B) for the 2005 Mars Reconnaissance Orbiter (MRO). MRO is the ultimate reconnaissance tool in the *Seek, In-situ, and Sample* strategy. MRO will narrow the focus into the localities identified as most promising by MGS and Odyssey, searching for the most compelling environmental indicators that a particular area was once suitable for bearing life (warm, wet, chemically benign, etc.).
- Preformulation phases for Mars missions beyond 2005, including a competitively selected 2007 Mars Scout mission, a highly capable 2007 Mars Smart Lander and Mobile Laboratory mission, and U.S. contributions to foreign Mars missions.
- Mars Technology to lay the groundwork and provide new capabilities for the Mars missions beyond 2005. The Jet Propulsion Laboratory, other NASA centers, and competitively selected industry and academic partners are actively engaged in developing new technology to unlock the mysteries of the Martian climate and geological history. The teams creating Mars exploration

technology combine novel uses of existing technology with cutting-edge advances in new areas of research to develop effective, low-cost solutions. The technology investment in this area will fund precision atmospheric entry and landing techniques, hazard avoidance systems, new in-situ sensors, and other ascent and mobility systems.

- Construction of a Deep Space Network (DSN) 34-meter Beam-Wave-Guide (BWG) Antenna and other DSN upgrades to reduce overloading problem during Mars and other OSS missions' critical activities.

SCHEDULE & OUTPUTS

Mars 2001 Orbiter and Lander

Orbiter & Lander ATLO Start Plan: 1st Qtr FY 2000 Revised: 1st Qtr FY 2000	Begin Assembly, Test and Launch Operations (ATLO) by integrating major components of the spacecraft into the spacecraft structure. Assembly, test and launch operation for the Orbiter mission started on time. However, the assembly, test and launch operations for the Lander did not occur since this mission was cancelled.
Orbiter & Lander Science Instruments Plan: 3rd Qtr., FY 2000 Actual/Revised: Orbiter: 3rd Qtr., FY 2000 Lander: late FY 2001	Deliver Mars 2001 Orbiter and Lander science instruments that meet capability requirements. The Mars '01 Orbiter portion of the target was accomplished; all work is proceeding on schedule to support an April 2001 launch. Orbiter instruments were delivered, and assembly and testing began on time. The Mars '01 Lander was cancelled due to program redesign after the loss of the Mars '98 spacecraft; however, the Lander instruments are to be used on the '03 Lander mission, and will be delivered in late FY01.
Ship Orbiter Plan: 1st Qtr FY 2001 Revised: 2nd Qtr FY 2001	Ship to VAFB launch site. The Odyssey orbiter shipped in January 2001, a one month delay. Additional schedule was provided by the launch site change from VAFB to CCAFS in response Red-Team recommendations.
Ship Lander Plan: 2nd Qtr., FY 2001 Revised: Lander cancelled	Ship to KSC launch site. The Mars '01 Lander was indefinitely postponed due to program redesign after the loss of the Mars '98 spacecraft.
Orbiter Launch Plan: March 2001 Revised: April 2001	Launch on schedule. One-month delay is due to implementation of Red-Team recommendations. (Additional schedule provided by the launch site change from VAFB to CCAFS.)

Lander Launch Plan: April FY 2001 Revised: Lander cancelled	Launch on schedule. The Mars '01 Lander was indefinitely postponed due to program redesign after the loss of the Mars '98 spacecraft. The Mars '01 Lander instruments will be flown on the '03 MERs.
<u>2003 Mars Exploration Rover (MER)</u>	
Mars Exploration Rover '03 Plan: FY 2002	Initiate assembly, test, and launch operations (ATLO) process. Assuming the Mars Exploration Program architecture is confirmed, meet the milestones for the Mars '03 instrument selection and initiate implementation of the Lander mission. Failure of the two Mars '98 spacecraft led to the Mars Surveyor Program redesign. However, milestones for Mars '03 instrument selection and Lander mission implementation have been accomplished.
<u>2005 Mars Reconnaissance Orbiter (MRO)</u>	
Mars Reconnaissance Orbiter '05 Plan: FY 2002	Select payload and initiate development. Deliver engineering models of the radio-frequency subsystem and antennae for the radar sounder instrument to ESA (if ESA approves the Mars Express mission), and select the contractors for the major system elements of the Mars Surveyor '05 mission. Engineering models for Mars Express were shipped two weeks into the new fiscal year (FY01). The Mars Exploration Program architecture was approved in November 2000; selections for the '05 mission are planned for FY 2002.

ACCOMPLISHMENTS AND PLANS

The Mars Surveyor Program completed restructuring activities in November 2000. To reflect the significance in the changes to the program, the Mars Surveyor Program name has been changed to Mars Exploration Program (MEP).

The '98 Mars Climate Orbiter (MCO) and Mars Polar Lander (MPL) launched successfully in December 1998 and January 1999; however, both missions failed upon arrival at Mars.

Spacecraft and instrument development for the Mars 2001Odyssey were completed and the systems were delivered for integration and test in the 4^{th} Quarter of FY 2000. The assembled spacecraft and instruments were shipped to Cape Canaveral in January 2001. Launch is scheduled for April 2001.

The 2003 Mars Exploration Rover (MER) was selected on August 10, 2000. A Preliminary Design Review (PDR) was completed on February 2, 2001, and the project entered Phase C/D on February 25, 2001.

The 2005 Mars Reconnaissance Orbiter (MRO) entered the formulation phase in the 2nd Quarter of FY 2001. A Request For Proposals (RFP) for the spacecraft and an Announcement of Opportunity (AO) for the science instruments will be released during the 3rd. Quarter of FY 2001.

A Request for Proposals (RFP) for construction of the new 34-meter DSN antenna will be released in the 3rd quarter of FY 2001. The Critical Design review (CDR) for the antenna will occur in late calendar year 2002. The antenna construction will begin at Madrid in 2002. Procurements of long-lead-time electronic components, such as recorders and high-power transmitters, will also be initiated in FY 2002. The antenna will become operational in FY 2003, in time to support the MER missions.

BASIS OF FY 2002 FUNDING REQUIREMENT

MISSION OPERATIONS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
HST operations	2,100	1,497	1,600
Other mission operations	76,600	83,806	103,700
Total	78,700	85,303	105,300

PROGRAM GOALS

The goal of the Mission Operations program is to maximize the scientific return from NASA's investment in spacecraft and other data collection sources. The Mission Operations effort is fundamental to achieving the goals of the Office of Space Science program, because it funds the operations of the data-collecting hardware that produces scientific discoveries. Funding supports satellite operations during the performance of the core missions, plus extended operations of selected spacecraft.

STRATEGY FOR ACHIEVING GOALS AND SCHEDULE & OUTPUTS

The Mission Operations program is working to dramatically reduce costs while preserving, to the greatest extent possible, science output. To do so, it will accept prudent risk, explore new conceptual approaches, streamline management and make other changes to enhance efficiency and effectiveness. The following is a comprehensive list of all Space Science spacecraft that are, or are expected to be, operational at any time between January 2001 and September 2002.

Advanced Composition Explorer, ACE (launched August 25, 1997; operations expected beyond FY 2002)
ACE is measuring the composition of the particles streaming from the Sun and of high-energy galactic cosmic rays.

Cassini (launched October 15, 1997; operations expected through ~ 2008)
Cassini will conduct a detailed exploration of the Saturnian system including: 1) the study of Saturn's atmosphere, rings and magnetosphere; 2) remote and in-situ study of Saturn's largest moon, Titan; 3) the study of Saturn's other icy moons; and 4) a Jupiter fly-by to expand our knowledge of the Jovian System. During the transit from Jupiter to Saturn, Cassini will conduct unique radio-science measurements designed to detect ripples of gravitational field produced by catastrophic events in the galaxy. Cassini will arrive at Saturn in 2004.

Chandra X-ray Observatory, CXO / Advanced X-ray Astrophysics Facility, AXAF (launched on July 23, 1999; operations expected through ~ FY 2009)

The objectives of Chandra are to: obtain high-resolution x-ray images and spectra in the 0.1-to-10-KeV wavelength range; investigate the existence of stellar black holes; study the contribution of hot gas to the mass of the universe; investigate the existence of dark matter in galaxies; study clusters and superclusters of galaxies; investigate the age and ultimate fate of the universe; study mechanisms by which particles are accelerated to high energies; confirm the validity of basic physical theory in neutron stars; and investigate details of stellar evolution and supernovae.

Comet Nucleus Tour, CONTOUR (launch scheduled summer 2002; operations expected beyond FY 2002)
CONTOUR will dramatically improve our knowledge of key characteristics of comet nuclei, and assess their diversity, by making close approaches to at least two comets.

Cooperative Astrophysics and Technology Satellite, CATSAT (launch scheduled winter 2001/2; operations expected beyond FY 2002)
CATSAT is a University-class Explorer that will study the origin and nature of Gamma Ray Bursters, one of the most mysterious astrophysical phenomena.

Cosmic Hot Interstellar Plasma Spectrometer, CHIPS (launch scheduled summer 2002; operations expected beyond FY 2002)
CHIPS will use an extreme ultraviolet spectrograph during its one-year mission to study the "Local Bubble," a tenuous cloud of hot gas surrounding our Solar System that extends about 300 light-years from the Sun

Deep Space 1, DS1 (launched October 24, 1998; operations expected to end in FY 2002)
Deep Space 1 has completed 100% of the testing required to validate its new technologies, and the mission has been extended, with a new focus on gathering scientific information during a fly-by of comet Borelly in September 2001.

Far Ultraviolet Spectroscopic Explorer, FUSE (launched June 24, 1999; expected operations beyond FY 2002)
The objectives for the FUSE mission are to measure abundances of deuterium produced by the Big Bang, the Milky Way, and distant galaxies; determine the origin and temperature of galactic gaseous clouds and observe interaction between the solar wind and planetary atmospheres.

Fast Auroral Snapshot, FAST (launched August 21, 1996; operations expected through FY 2001)
FAST is a low-altitude, polar-orbiting satellite designed to measure the electric fields and rapid particle accelerations that occur along magnetic field lines above auroras. Extremely high data rates (burst modes) are required to detect the presence and characteristics of the fundamental effects taking place.

Galaxy Evolution Explorer, GALEX (launch scheduled in 2nd. QTR of FY 2002, expected operations beyond FY 2002)
GALEX will use an ultraviolet telescope during its two-year mission to explore the origin and evolution of galaxies and the origins of stars and heavy elements, and to detect millions of galaxies out to a distance of billions of light-years. GALEX will also conduct an all-sky ultraviolet survey.

Galileo (launched October 18, 1989; operations expected through August 2003)
Galileo is executing a series of close flybys of Jupiter and its moons, studying surface properties, gravity fields and magnetic fields, and characterizing the magnetospheric environment of Jupiter and the circulation of its Great Red Spot. In December 1997, the program finished its primary mission and began the Galileo Europa Mission (GEM), a detailed study of Jupiter's ice-covered moon. Galileo completed the GEM in January and began its "Galileo Magnetosphere Mission" (GMM]. This extension enabled unique science investigations in coordination with the Cassini fly-by of Jupiter in December 2000, has generated unique engineering data on the performance of the spacecraft in high-radiation-dosage environments, and is providing a detailed study of the volcanic moon IO and the inner Jovian magnetosphere. Galileo will end its mission in August 2003 with a Jupiter Impact.

Genesis (launch scheduled July 2001; operations expected to end in FY 2004)
The Genesis mission will collect samples of charged particles from the solar wind and return them to Earth laboratories for detailed analysis.

High Energy Solar Spectroscopic Imager, HESSI (launch scheduled April 2001, operations expected beyond FY 2002)
HESSI will observe the Sun to study particle acceleration and energy release in solar flares.

High Energy Transient Explorer 2, HETE-2 (launched October 08, 2000; operations expected beyond FY 2002)
The primary goal of HETE-2 is to determine the origin and nature of cosmic gamma-ray bursts.

Hubble Space Telescope, HST (launched April 25, 1990; operations expected through ~2010)
HST science operations are carried out through an independent HST Science Institute, which operates under a long-term contract with NASA. Satellite operations, including telemetry and initial science data acquisition are performed on-site at Goddard Space Flight Center under separate contract. While NASA retains operational responsibility for the observatory, the Science Institute plans, manages, and schedules the scientific and science related flight operations.

Imager for Magnetopause-to-Aurora Global Exploration, IMAGE (launched March 25, 2000, operations expected through FY 2002)
IMAGE will study the global response of the Earth's magnetosphere to the changes in the solar wind.

International Solar-Terrestrial Physics, ISTP: Geotail (launched July 24, 1992; operations expected beyond FY 2002), Wind (launched November 1, 1994; operations expected beyond FY 2002), Polar (launched February 24, 1996; operations expected beyond FY 2002), Solar and Heliospheric Observatory (SOHO) (launched December 2, 1995; operations expected beyond FY 2002), Cluster-II (launched July 16 and August 9, 2000; operations expected beyond FY 2002).

Geotail is a Japan-U.S. spacecraft that is exploring the near-tail region on the night side and the magnetopause on the day side of the Earth. Wind measures the energy, mass, and momentum that the solar wind delivers to the Earth's magnetosphere. Polar provides dramatic images of the aurora and complementary measurements to provide a direct measure of the energy and mass deposited from the solar wind into the polar ionosphere and upper atmosphere. SOHO studies the solar interior by measuring the seismic activity on the surface; SOHO also investigates the hot outer atmosphere of the Sun that generates the variable solar wind, as well as UV and X-ray emissions affecting the Earth's upper atmosphere, the geospace environment, and the heliosphere. The four ESA/NASA Cluster spacecraft are carrying out three-dimensional measurements in the Earth's magnetosphere, covering both large- and small-scale phenomena in the sunward and tail regions.

Interplanetary Monitoring Platform-8, IMP-8 (launched October 26, 1973; operations expected beyond FY 2002)
IMP-8 performs near-continuous studies of the solar wind and the interplanetary environment for orbital periods comparable to several rotations of the active solar regions.

Mars Global Surveyor (launched November 7, 1996; expected operations beyond FY 2002)
MGS studied the Martian topography, seasonal changes, and internal and atmospheric structures for a complete Martian year (March 1999 through January 2001). During its prime mission, MGS collected more information about the red planet than all previous missions combined. MGS completed its primary mission on January 31, 2001, and moved immediately into an extended mission phase. In the extended phase MGS will study the most interesting locations on the planet in detail and observe variability on the Martian surface. MGS will also study potential landing sights for the Mars 2003 rovers.

2001 Mars Odyssey (launch scheduled April, FY 2001; expected operations beyond FY 2002)
The Mars 2001 Odyssey science objective is to determine the elemental and mineral composition of the Martian surface, learn about the landforms, and measure the potential radiation hazards for future human exploration. The 2001 Mars Odyssey Orbiter is scheduled for launch in April 2001, will arrive at Mars in October 2001, and will begin mapping activities 45-to-90 days after orbit capture.

Microwave Anisotropy Probe, MAP (launch scheduled summer 2001, operations expected beyond FY 2002)
The MAP Mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos.

Near Earth Asteroid Rendezvous, NEAR (launched February 17, 1996; operations ended February 2001)
NEAR completed its one year orbital mission around the asteroid Eros with a soft landing on the asteroid on February 12, 2001. Initial data analysis will be completed in FY 2001, followed by a competitive Guest Investigator program.

Rossi X-ray Timing Explorer, RXTE (launched December 30, 1995; expected operations beyond FY 2002)
RXTE observes the fast-moving, high-energy worlds of black holes, neutron stars, X-ray pulsars and bursts of X-rays that light up the sky and then disappear forever.

Solar Anomalous and Magnetospheric Particle Explorer, SAMPEX (launched July 3, 1992; operations expected through FY 2002)
SAMPEX is measuring the composition of solar energetic particles, anomalous cosmic rays, and galactic cosmic rays.

Space Infrared Telescope Facility, SIRTF (launch scheduled summer 2002, operations expected beyond FY 2002)
SIRTF, the last of NASA's four Great Observatories, will be a cryogenically cooled observatory to conduct infrared astronomy from space. Incorporating the latest in large-format infrared detector array technology, SIRTF will do for infrared astronomy what the Hubble Space Telescope has done in its unveiling of the visible universe.

Stardust (launched February 7, 1999; expected sample return to Earth in 2006)
Stardust flew by Earth for its final gravity assist in January 2001, and continues on its five-year cruise to rendezvous with Comet Wild-2, in January 2004.

Submillimeter Wave Astronomy Satellite, SWAS (launched December 5, 1998; expected operations through January 2002)
SWAS is designed to study the chemical composition of interstellar gas clouds. Its primary objective is to survey water, molecular oxygen, carbon, and isotopic carbon monoxide emission in a variety of galactic star forming regions.

Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics, TIMED (launch scheduled summer 2001; operations expected beyond FY 2002)
TIMED will explore the Earth's Mesosphere and Lower Thermosphere (60-180 kilometers), the least explored and understood region of our atmosphere.

Transition Region and Coronal Explorer, TRACE (launched April 1, 1998; operations expected beyond FY 2002)
TRACE observes, with high resolution, the effects of the emergence of magnetic flux from deep inside the Sun to the outer corona.

Ulysses (launched October 6, 1990; operations expected beyond FY 2002)
Ulysses is transiting the solar poles during 2001, during the peak of the current solar maximum period. The spacecraft is measuring solar wind properties at high latitudes and is providing a unique 3-dimensional perspective of the heliosphere.

Voyager Interstellar Mission (Voyager 1 launched September 5, 1977; Voyager 2 launched August 20, 1977; operations expected beyond FY 2002)
Voyager 1 and 2 are traveling beyond the planets, continuing to probe the outer heliosphere searching for the boundary between the solar system and interstellar space.

NASA also participates in the following international missions. The foreign partners provide for the operations costs of these missions, with NASA providing science contributions.

- **Beppo-SAX (launched April 30, 1996; operations expected beyond FY 2002)**
- **Highly Advanced Laboratory for Communications and Astronomy, HALCA (launched February 12, 1997; operations expected to end FY 2002)**
- **International Gamma-Ray Astrophysics Laboratory, INTEGRAL (launch scheduled April 2002; operations expected beyond FY 2002)**
- **Nozomi (launched July 3, 1998; operations expected beyond FY 2002)**

- **X-ray Spectroscopy Mission, XMM (launched December 10, 1999; operations expected beyond FY 2002)**
- **Yohkoh (launched August 31, 1991; operations expected beyond FY 2002)**

ACCOMPLISHMENTS AND PLANS

Space Science continues to make progress in lowering mission operations costs while preserving the science return from operating missions. The program is utilizing the savings, and seeking additional cost reductions, in order to sustain operations of ongoing missions as long as is merited by the science return. The science community both inside and outside of NASA regularly reviews the mission operations program to ensure that only the missions with the highest science return are funded. In addition, we are launching smaller spacecraft, and engaging in more international collaborations. As of the end of January 2001, there are 24 operational Space Science missions (25 spacecraft), in addition to participation in six foreign missions (nine spacecraft).

At the end of FY 2002,we expect to have 33 operational Space Science spacecraft, in addition to participation in the operations of nine foreign spacecraft. Missions expected to begin operations before the end of FY 2002 include 2001 Mars Odyssey (04/01), HESSI (spring 2001), Genesis (summer 2001), MAP (summer 2001), TIMED (summer 2001), CATSAT (winter 2001/2), GALEX (early 2002), INTEGRAL (spring 2002), CONTOUR (summer 2002), SIRTF (summer 2002), and CHIPS (summer 2002).

TECHNOLOGY CROSSWALK from FY 2001 to FY 2002

SUPPORTING RESEARCH AND TECHNOLOGY	TECHNOLOGY PROGRAM
Core Program	Core Program
Focused Programs	Focused Programs
Astronomical Search for Origins	Astronomical Search for Origins
[Construction of Facilities]	[Construction of Facilities]
Solar System Exploration	Solar System Exploration
Sun-Earth Connections	Sun-Earth Connections
Structure & Evolution of the Universe	Structure & Evolution of the Universe
New Millennium Program	New Millennium Program
	RESEARCH PROGRAM
Research and Analysis	Research and Analysis
Data Analysis	Data Analysis
Suborbital	Suborbital
Balloon Program	Balloon Program
Sounding Rockets	Sounding Rockets

BASIS OF FY 2002 FUNDING REQUIREMENT

TECHNOLOGY PROGRAM

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Technology Program	581,200	419,245	478,800
Core Program	245,200	96,487	108,000
Focused Programs	322,200	301,105	307,000
Astronomical Search for Origins	117,600	111,055	193,500
[Construction of Facilities]	[2,500]	[490]	
Solar System Exploration	156,400	112,421	48,600
Sun-Earth Connections	24,800	52,484	49,100
Structure & Evolution of the Universe	23,400	25,145	15,800
New Millennium Program	13,800	21,652	63,800

PROGRAM GOALS

The goals of the Technology Program are to: (1) lower mission life-cycle costs; (2) provide new scientific capabilities; (3) develop and nurture an effective science-technology partnership; (4) stimulate cooperation among industry, academia, and government; and (5) identify and fund the development of important cross-Enterprise technologies.

STRATEGY FOR ACHIEVING GOALS

TECHNOLOGY

The Space Science Enterprise's Technology Program consists of three major elements: core programs, focused programs, and flight validation. These elements are designed to develop technologies from the conceptual stage to the point where they are ready to be incorporated in the full-scale development of science mission spacecraft.

Core Programs are comprised of two major components: Space Science Technology and Cross-Enterprise Technology, which has been transferred to the Aero-Space Technology Enterprise in FY 2001 and beyond.

Space Science Technology provides for several activities that cover a broad range of baseline technological capabilities supporting multiple applications. Most of the funding in this area provides for computation and information technologies. Other core capabilities, such as ground system hardware and software for deep space missions, are also included in this area. The elements of the Space Science Technology Program are described below:

- Information Systems provides technology for multidisciplinary science support in the areas of data management and archiving, networking, scientific computing, visualization, and applied information systems research and technology.

- The Remote Exploration and Experimentation (REE) project, a part of the NASA High-Performance Computing and Communications Program has been working to develop low-power, fault-tolerant, high-performance, scaleable computing technology for a new generation of microspacecraft. Funding for this activity is ending at the end of FY 2001 as a result of policy and budget prioritization decisions.

- The Planetary Flight Support (PFS) program provides ground system hardware, software, and mission support for all deep-space missions. Planetary Flight Support has recently focused on the design and development of multi-mission ground operation systems for deep space and high-Earth-orbiting spacecraft, including generic multi-mission ground system upgrades such as the Advanced Multi-Mission Operations System (AMMOS). This new capability is designed to significantly improve our ability to monitor spacecraft systems, resulting in reduced workforce levels and increased operations efficiencies for Cassini and future planetary missions. New missions in the Discovery and Mars Surveyor programs will work closely with the Planetary Flight Support Office to design ground systems developed at minimum cost, in reduced time, with greater capabilities, and able to operate at reduced overall mission operations costs.

- Additional funding provided in the President's FY 2002 Budget also supports key In-Space Propulsion technology investments that will enable faster and more capable future planetary missions such as a future sprint mission to the planet Pluto by 2020. Key technologies to be included in this line may include advanced electric and nuclear propulsion systems.

- Other Space Science Core Technology provides funding to those technologies that are applicable to multiple science themes within OSS. Technologies eventually move from this category into a focused program (described below) when they have successfully been demonstrated and are ready for infusion into a focused program mission.

- The Intelligent Systems Program will provide NASA with autonomous and semi-autonomous computational capabilities to enable future missions in deep space, planetary exploration, aerospace applications, and Earth observing systems and data understanding. In FY 2001 the Intelligent Systems Program was transferred to the Aero-Space Technology Enterprise.

Although most of the Cross-Enterprise Technology program was transferred to the Aero-Space Technology Enterprise, a few elements that are critical to Space Science remain here. These remaining activities are Gossamer Spacecraft and Next Decade Planning, as well as the Congressionally mandated Space Solar Power activities.

- The Gossamer Spacecraft initiative supports efforts to develop and demonstrate the deployment, control, and utility of ultra-light, thin-film, deployable structures and space observatories. Technologies developed in this area could support several future applications: solar sail propulsion, large-aperture astronomical observatories, large-aperture remote sensing, large-scale power collection and transmission in space, and interstellar precursor missions.

- Next Decade Planning is supporting intra-agency planning to develop and refine a robust set of potential civil space programs that could be undertaken in the next decade. This planning effort will result in roadmaps that will aid in selecting technologies aimed at enabling these future programs.

- Space Solar Power is developing goals and objectives, detailed roadmaps, and technology investment priorities through ongoing studies and initial technology activities. Although funded in the Space Science budget by Congress, this project is managed by the Office of Space Flight.

Focused Programs are dedicated to high-priority technologies needed for specific science missions. An aggressive technology development approach is used that requires all major technological hurdles to be cleared prior to a science mission's development phase. Technology activities can encompass developments from basic research all the way to infusion into science missions. Focused Programs also includes mission studies -- the first phase of the flight program development process. Scientists work collaboratively with technologists and mission designers to develop the most effective alignment of technology development programs with future missions. This collaboration enables intelligent technology investment decisions through detailed analysis of the trade-offs between design considerations and cost. In order to ensure that the decisions resulting from mission studies are realistic and can be implemented, the studies will employ new techniques for integrated design and rapid prototyping.

The FY 2002 budget estimate includes four categories of activities under focused programs. These categories correspond to the four scientific themes of the Space Science Enterprise: Astronomical Search for Origins, Solar System Exploration (formerly known as Advanced Deep Space Systems Development), Sun-Earth Connections, and Structure and Evolution of the Universe. These elements are described below:

- Astronomical Search for Origins Technology develops critical technologies for studies of the early universe and of extra-solar planetary systems. Included are large lightweight deployable structures, precision metrology, vibration isolation and structural quieting systems, optical delay lines and large lightweight optics. Missions supported in this area include the Space Interferometry Mission (SIM), Next Generation Space Telescope (NGST), and Terrestrial Planet Finder (TPF), as well as the provision of interferometry capability to the ground-based Keck telescopes. This line also funds construction of the Optical Interferometry Development Laboratory at the Jet Propulsion Laboratory.

- Solar System Exploration (formerly known as Advanced Deep Space Systems Development) provides for the development, integration, and testing of revolutionary technologies for the Outer Planets Program (OPP) and development and launch of missions to the outer planets. Technology funded within this line includes micro-avionics and advanced power systems. Funding for spacecraft currently under development includes the Europa Orbiter (EO) Mission.

- Sun-Earth Connections (SEC) focused program formulates missions to investigate the effects of solar phenomena on the space environment and on the Earth. Missions funded in this area that are now under study include STEREO (funded as a separate major mission beginning in FY 2002; see page SAT 1-23 above), Solar B, and Solar Dynamics Observatory, as well as future SEC missions. The FY 2002 budget includes two programs, Solar Terrestrial Probes Program and Living With a Star. The Solar Terrestrial Probes Program focuses on studying the Sun and Earth as an integrated system to address the scientific questions of how and why the Sun varies and how the Earth and planets respond. Living With a Star, a new program in FY 2001, is a set of missions, analysis, and testbeds designed to develop the scientific understanding of how the connected Sun-Earth system affects life and society. Understanding the connected system becomes more important as we increase our dependence on space-based systems and assets and look toward a future permanent human presence in space. The Living With a Star Program capitalizes upon investments made in the Solar Terrestrial Probes Program in missions such as TIMED, STEREO, and Solar-B as well as the ST-5 nanosat technology validation project in the Flight Validation Program. LWS will also leverage partnerships with other federal agencies.

- Structure and Evolution of the Universe Technology provides for the development of technologies to study the large-scale structure of the universe, including the Milky Way, and objects of extreme physical conditions. SEU missions are aimed at explaining the cycles of matter and energy in the evolving universe, examining the ultimate limits of gravity and energy in the universe and forecasting our cosmic destiny. Technology funded in this area supports missions now under study, such as Herschel (formerly named FIRST) and GLAST (funded as a separate major mission beginning in FY 2002; see page SAT 1-25 above). Additional funding provided in the President's FY 2002 Budget supports technology for development decisions on future SEU missions, particularly Constellation-X and LISA.

Focused Program Missions	Implementation Start	FY 2000	FY 2001	FY 2002
Origins				
SIM	FY 2003	39,225	30,300	30,800
NGST	FY 2004	48,650	45,200	92,100
TPF	FY 2008	4,000	5,500	7,300
Starlight (formerly ST-3)	TBD	8,000	14,500	48,400
Keck Interferometer	FY 1998	13,700	9,800	7,800
Solar System Exploration				
Europa Orbiter	FY 2004	32,500	96,100	48,600
Structure & Evolution of the Universe				
FIRST	FY 2001	16,100	15,500	[14,600]
GLAST	FY 2002	4,900	4,700	[19,400]
Constellation-X	TBD	1,600	1,596	TBD
LISA	TBD			TBD
Sun-Earth Connections				
MMS	FY 2005	400	700	6,500
GEC	FY 2005	100	400	500
MC	FY 2007	100	400	500

The **New Millennium Program** provides a path to flight-validate key emerging technologies to enable exciting science missions. Through the New Millennium Program, high-value technologies are made available for use in the Space Science program without imposing undue cost and risk on individual science missions. This program was restructured to increase its levels of openness and competitiveness, to reduce the size and cost of the missions, and to ensure focus on technology demonstration, versus science data gathering. The program includes validation of both complete systems and subsystems. NASA plans to enable two small ($40-50 million each) and one medium ($100-150 million) system validations every four years, along with two-to-three subsystem validations per year, including carrier and secondary launch. Partnerships with industry, universities, and other government agencies are pursued, where feasible, to maximize both the return on investment in technology development and rapid infusion.

SCHEDULE & OUTPUTS

Core Program

First-Generation computing testbed Plan: 2nd Qtr FY 1999 Revised: 3rd Qtr FY 2000 Revised: TBD	For HPCC Remote Exploration and Experimentation (REE) program, install first-generation scaleable embedded computing testbed operating at 30-200 MOPS/watt. Difficulties with the hardware design have delayed delivery. *Delivery of the first-generation embedded computing testbed was delayed due to hardware problems. It was delivered in November 2000. Demonstration is expected in late FY 2001. Funding for HPCC/REE was terminated in FY 2002 to support other priorities. The impact of the termination on the completion of this activity is still under examination.*
Demonstrate scaleable computer for spaceborne applications Plan: 3rd Qtr FY 1999 Revised: 4th Qtr FY 2000 Revised: TBD	For HPCC Remote Exploration and Experimentation (REE) program, demonstrate scaleable spaceborne applications on a first-generation embedded computing testbed. *All of the applications have been delivered and demonstrated on a commercial parallel computer and are awaiting delivery of the testbed.* *Delivery of the first-generation embedded computing testbed was delayed due to hardware problems; delivered in November 2000. Demonstration is expected in late FY 2001. Funding for HPCC/REE was terminated in FY 2002 to support other priorities. The impact of the termination on the completion of this activity is still under examination.*
HPCC Plan: FY 2001 Revised: TBD	Demonstrate a real time capability with software-implemented fault tolerance for embedded scalable computers. Real time performance latencies of less than 20 milliseconds are to be sustained at fault rates characteristic of deep space and low-Earth orbit (LEO). *HPCC/REE funding was decreased in FY 2001 to provide support for other OSS priorities. As a result, scheduled completion of this activity was delayed until FY 2002. . Funding for HPCC/REE was terminated in FY 2002 to support other priorities. The impact of the termination on the completion of this activity is still under examination.*

Information Systems Plan: FY 2000 Actual: FY 2000	Information Systems R&T will demonstrate the search, discovery, and fusion of multiple data products at a major science meeting. *Data products were successfully demonstrated at American Astronomical Society (AAS) and American Geophysical Union (AGU) meetings.*
Information Systems Plan: FY 2000 Actual: FY 2000	Information Systems R&T will accomplish and document the infusion of five information systems R&T efforts into flight projects for the broad research community. *Infusion of information systems R&T efforts included: (1) Computational tools developed under AISRP, which were used for BOOMERANG and MAXIMA data analysis; (2) Physics-based modeling/simulation, which was used for MICAS camera on DS-1; (3) PIXON method image reconstruction, which was used for Chandra and other flight mission data; (4) Precision Mining of Hyperspectral Data, which was applied for Mars mission data analysis; (5) SkyView virtual telescope capability, which was incorporated into mainstream HEASARC data center services; and (6) Science Expert Assistant, which was adopted by STScI for production use with HST observing program.*
Information Systems Plan: FY 2001 Revised: FY 2001 and FY 2002	Information Systems R&T will demonstrate Virtual Observatory capability from an investigator workstation for multi-wavelength discovery, analysis and visualization across a collective set of space and ground astronomical surveys; and will demonstrate a Virtual Mars capability simulating rovers navigating Mars terrain, for planning and design of Mars '03 and '05 missions. *Virtual Observatory demonstration will be completed in FY 2001. However, the Virtual Mars demonstration will not be completed until FY 2002, due to reallocation of funding to higher priority projects.*
Explorer Program Technology Plan: FY 2001	Complete 45 Explorers Technology Investigations selected in FY99. *These 45 investigations are funded; 43 have been completed. All 45 selected investigations will be completed by the 3rd quarter of FY 2001.*
Explorer Program Technology Plan: FY 2001	Implement awards for additional investigations planned for selection in FY 2000. *The FY00 Explorer NRA was not released due to redirection of funding to Explorer missions to address issues identified by Red Team reviews.*

Cross-Enterprise Technology: Develop Wide-Band Low-Power Electronically-Tuned Local Oscillator Sources up to 1.3 THz Plan: 3rd Qtr FY 1998 Revised: 3rd Qtr FY 2000 Actual: 4th Qtr FY 2000	A wide-band local oscillator (with 15% bandwidth) has been demonstrated operating at frequencies up to 0.5 THz. Construction of components operating at higher frequencies is underway. Lab demonstration of local oscillators operating at frequencies up to 1.9THz is planned for 3RD Qtr FY 2000. *Technology approach and development schedule changed to reflect new advances in amplifier technology. Baselined technology on FIRST mission.*
Cross-Enterprise Technology: Task Selections Plan: 4th Qtr FY 2000 Actual: 1st Qtr FY 2001	Select first set of tasks from NASA Research Announcement (NRA) for Cross-Enterprise technology development (released November 1999) following competitive review. *Selected 111 technologies from among 1229 proposals.*
Cross-Enterprise Technology: Task Selections Plan: FY 2001 Revised: N/A	Select second set of tasks from NASA Research Announcement (NRA) for Cross-Enterprise technology development (released November 1999) following competitive review. *Program management and funds transferred to the Office of Aerospace Technology, effective October 1, 2000.*
Cross-Enterprise Technology: Full and Open Competition Plan: End of FY 2000 Revised: FY 2001	One hundred percent of tasks subjected to full and open competition and/or external non-advocate review by end of FY 2000. *Program currently responding to Congressional inquiry; change in approach to percentage of competition.*

Focused Programs

Astronomical Search for Origins

Starlight (formerly ST-3) System Architecture Review Plan: August 1999 Revised: October 2000 Revised: FY 2001	System Architecture & Requirements Review. *Delay due to significant program rephasing and replanning to bring ST-3 and TPF schedules into alignment, resulting in extended Phase B for ST-3.*

Starlight (formerly ST-3) Technology Development Plan: FY 2001 Revised: PDR FY 2002 CDR FY 2003	Successfully complete PDR as well as project and spacecraft CDR. *Delay due to significant program rephasing and replanning to bring ST-3 and TPF schedules into alignment, resulting in extended Phase B for ST-3.*
Space Interferometry Mission (SIM) Non-Advocate Review Plan: 2nd-4th Qtr FY 1999 Revised: 1st Qtr FY 2002 Revised: TBD	Conduct the preliminary non-advocate review of the high-precision astrometry and synthetic aperture imaging technologies for space-based interferometers. Key features include optical collectors on a 10-meter baseline and 10-milli-arcsecond synthesized imaging. *Study of revised mission concepts is underway; the schedule for a NAR cannot be determined until this activity is completed.*
SIM Nulling Demonstration Plan: FY 2001 Actual: N/A	Demonstrate stabilization for nulling to one nanometer. Nulling is required to remove starlight that would wash out SIM's view of planets in other solar systems. *Decision made in October 2000 to eliminate the requirement for nulling demonstration in space by SIM. A ground demonstration of <10 nanometers which eliminated the need for additional space and ground nulling demonstration for SIM.*
SIM Testbed Demonstration Plan: FY 2002	Use the Microarcsecond Metrology (MAM-1) Testbed to demonstrate metrology at the 200-picometer level with white light fringe measurements. Accomplishing this level of performance is required in order for SIM to identify multi-planet solar systems out to 10 parsecs.
SIM SRR Plan: FY 2001 Revised: TBD	Complete System Requirements Review (SRR) and, initiate Phase B *Study of revised mission concepts is underway; the schedule for SRR and Phase B initiation cannot be determined until this activity is completed.*
Keck Fringe Detection Plan: FY 2000 Revised: FY 2001	Development of the interferometer program for connecting the twin Keck 10-meter telescopes with an array of four two-meter class outrigger telescopes will be tested by detecting and tracking fringes with two test siderostats at two- and ten-micron wavelengths. *Replace the entire italicized explanation with: Deliveries of all hardware items to the Keck site on Mauna Kea occurred on time. However, installation of these components into a working system took longer than expected, due to a number of technical problems (e.g., relay mirror optics alignment, optical bench vibration amplification) that had not occurred in the lab at sea level.*
Keck Technology Development Plan: FY 2001	Combine 2 Keck telescopes; install first outrigger telescope. *Efforts to combine the 2 telescopes continue on schedule. However, delays have been encountered in the permitting process for the outrigger telescope. [State and federal level permits required; federal*

Revised: Outrigger: TBD	*includes National Environmental Protection Act (NEPA) and National Historic Preservation Act (NHPA) requirements.]*
NGST Technology Testbed Development Plan: FY 2000 Revised: N/A (approach altered)	Complete the NGST Developmental Cryogenic Active Telescope Testbed (DCATT) phase 1, measure ambient operation with off-the-shelf components, and make final preparations for phase 2, the measurement of cold telescope operation with selected "flight-like" component upgrades. *These technologies are critical to the operation and optimization of segmented optics, which we envision will be used by NGST and other telescopes. DCATT Phase 0 was successful. However, Phase 1 was not successful due primarily to problems with the segmented 1-meter telescope addition. As a result of these problems, the wavefront sensing and control effort was changed (both management and testbed approach) in October 1999 to correct the problems in the original DCATT effort. The new program involves a mix of in-house work and efforts by the prime industry teams to develop a series of Wavefront Control Testbeds (WCT) that develop, test and validate algorithms and processes for wavefront control.*
NGST Inflatable Sun Shield Development Plan: FY 2001 Revised: ISIS: cancelled	Inflatable Shield in Space (ISIS) ready to fly on Shuttle; release Announcement of Opportunity (AO) for Science Instrument; down-select to a single Phase 2 prime contractor. *ISIS cancelled after determination that technology would not be necessary for NGST.*
TPF Technology Development Plan: FY 2000 Revised: FY 2002	Complete and deliver a technology development plan for the Terrestrial Planet Finder (TPF) mission. This infrared interferometer requires the definition of technologies that will not be developed or demonstrated by precursor missions. *As part of an overall restructuring of the Origins program, the projected launch date for TPF was moved out two years to 2012 and NASA HQ readjusted the budget guidelines. As a result, the pre-project activities were replanned by JPL. Architecture definition studies were initiated in the 2Q of FY 2000 and the technology roadmap development was postponed until after these studies are completed in the 2nd Qtr. of FY 2002. As a result of HQ decisions to delay the TPF mission and the project replanning, the technology development roadmap will not be completed until FY 2002.*
TPF Architectural Definition Plan: FY 2001 Actual: FY 2000	Award architectural definition contracts. *Contracts were awarded in FY 2000 for Phase 1, with an option for Phase 2 studies. Phase 1 concepts were presented in December 2000. In January 2001, four of these were selected for Phase 2.*
TPF Phase 2 Industrial Contracts Plan: FY 2001 Actual: N/A	Develop RFP for second phase of industrial contracts. *Architectural definition contracts awarded in FY 2000 were for Phase 1, with an option for Phase 2 studies. (See above.) Phase 1 concepts were presented in December 2000. In January 2001, four of these were selected for Phase 2.*
TPF Starlight Nulling	Test Starlight nulling breadboard.

Plan: FY 2001	
TPF Architecture Plan: FY 2002	Provide studies and integrated models of mission architecture concepts.

Solar System Exploration

CISM Technology Plan: 3rd Qtr FY 2000 Revised: FY 2002	Deliver first engineering model of an integrated avionics system. *Although some elements of command and data handling were delivered, the remainder of the technology activity represented by the target is now being reformulated under the Outer Planets Program. The CISM effort has been realigned to development of lower level technology (Technology Readiness Levels 3 to 6).*
CISM Technology Plan: FY 2001	Demonstrate and deliver prototype advanced power transistor [0.35 micron SOI (Silicon On Insulator) CMOS (Complementary Metallic Oxide Semiconductor)].
CISM Active Pixel Sensor Plan: FY 2001 Actual: FY 2001	Demonstrate Active Pixel Sensor with advanced processing capabilities on a single chip. *Demonstration completed.*
X-2000 Technology Development Plan: FY 2000 Revised: FY 2002	The first engineering model (EM-1) of the X2000 First Delivery will be delivered. Successful development includes the integration of all EM-1 hardware, the functional verification of delivered hardware and software, and the ability to support ongoing testing, hardware integration, and software verification for delivered software. *Reformulation of the Outer Planets Program has now integrated the X2000 technology development activity into the Europa Orbiter Project. Delays to date in the X2000 have primarily been the result of design complexity and difficulty in integrating commercial intellectual property into the custom designs necessary to endure the extreme radiation expected in the space environment. In accordance with the reformulated schedule for the Europa Orbiter Project, the anticipated delivery date has moved to late FY 2002.*
X-2000 Technology Development Plan: FY 2001 Revised: FY 2002 for Engineering Model and FY2004 for Flight Hardware	Deliver engineering model and flight set of avionics. *Reformulation of the Outer Planets Program has now aligned the X2000 technology activity into the Europa Orbiter (EO) development effort. The anticipated delivery schedule for the engineering model avionics is now FY 2002, in accordance with the reformulated EO Project schedule. The delivery of flight avionics in support of the baselined 2008 EO launch is now scheduled for FY 2004.*

Solar System Exploration (non-Mars) First Mission C/D Start Plan: 1st Qtr FY 2001 Revised: TBD	Successfully complete a preliminary design for either the Europa Orbiter or Pluto-Kuiper Express mission (whichever is planned for earlier launch) that is shown to be capable of achieving the Category 1A science objectives with adequate cost, mass, power, and other engineering margins. ***Pluto-Kuiper Express:*** *Preliminary Design Review (PDR) was initially delayed due to increases in spacecraft mass and power resulting in the need for a larger launch vehicle. Concerns were also identified regarding launch vehicle qualification for launch of a spacecraft with a radioisotope power system. Mission life-cycle cost estimates exceeded available budget for a planned December 2004 launch. The project was not ready to proceed into development. A stop-work order was issued in September 2000.* ***Europa Orbiter:*** *Preliminary Design Review (PDR) delayed due to concerns in spacecraft mass, power, and avionics subsystems, and launch vehicle qualification for launch of a spacecraft with a radioisotope power system. Continued engineering design for avionics and power systems. Technology developments in power and avionics subsystems are anticipated to support a FY 2008 planned launch.*
Europa Orbiter Avionics Engineering Model I&T Plan: July 2000 Revised: 2002	Begin integration and test of the Avionics Engineering Model. *The schedule to begin integration and test of the Europa avionics engineering model is now FY 2002, in accordance with the reformulated Europa Orbiter Project schedule.*
Future Deep Space Systems Planning Plan: FY 2001	Deliver X-2000 Level 1-3 Requirements Documents, define subsystems, complete definition of system architecture.
Future Deep Space Multi-Functional Structures Plan: FY 2001 Actual: FY 2001	Demonstrate intermediate-level multi-functional structures (MFS). *Demonstration complete.*
Outer Planets Program Evaluation Plan: FY 2002	Complete evaluation and restructuring of Outer Planets Program.

SEC

Deliver Solar-B Electrical Engineering Models Plan: September 2000 Revised: June 2001	Complete and deliver for testing Solar-B's four Electrical Engineering Models. *As requested by the Japanese, delivery was delayed until June 2001 due to a Japanese-initiated launch delay. (Note: There was a typographical error in the original metric ; only three instruments were planned.)*
Deliver Solar-B Telescope Engineering Model Plan: FY 2001 Revised: FY 2002	Deliver engineering model of the optical telescope and x-ray telescope. *Delayed one year due to Japanese-initiated launch delay. (See above.)*
STEREO Technology Development Plan: FY 2000 Revised: FY 2001	Complete STEREO Phase A studies by June 2000, including the release of an AO for investigations with specific instruments and selection of the formulation phase payload. *AO was released. Specific instruments and the formulation phase payload were selected, and all included international Co-Investigators. Phase A studies were not completed. International Traffic in Arms Regulations (ITAR) requirements were tightened after the AO was issued; therefore, it was not possible to establish all of the necessary Letters of Agreement (LOAs) with foreign governments in time to avoid delaying completion of Phase A studies until FY 2001.*
STEREO Technology Development Plan: FY 2001	Successfully complete Phase B effort, including Confirmation Review.
Complete Living With a Star Strategic Plan Plan: March 2001 Actual: August 2000	Complete Living With a Star Project Strategic Plan, including mission architecture, for the OSS Strategic Plan.
Future ST Probes Technology Development Plan: FY 2001 Actual: January 2001	Complete preliminary concept definitions for spacecraft systems and instruments for Magnetospheric Multiscale.
Living With a Star/SDO Plan: FY 2002	Release AO (Announcement of Opportunity) for Solar Dynamics Observatory (SDO) mission.

SEU

Herschel (FIRST) Instrument Performance Plan: FY 2000 Revised: FY 2001	Demonstrate performance of the Superconductor-Insulator-Superconductor (SIS) mixer to at least 8hv/k at 1,120 GHz and 10hv/k at 1,200 GHz. The U.S. contribution to the ESA Herschel (FIRST) is the heterodyne instrument, which contains the SIS receiver. *Development of required local oscillator is late due to late delivery of a piece of test equipment, ordered from a German company. Expected to be accomplished by mid-FY 2001.*
Herschel (FIRST) Technology Development Plan: FY 2001 Actual: cancelled	Complete the qualification mirror (QM) fabrication. *The U.S. Herschel telescope activity was cancelled due to increased costs to meet additional ESA requirements, as well as cost increases in other, higher priority, SEU programs. ESA had requested the construction and delivery of a FIRST engineering model telescope, which would have increased NASA's costs by approximately $5 million. Moreover, increases in the costs of other, higher priority SEU activities reduced the amount of funds available for U.S. participation in the Herschel telescope activity. ESA has been developing an alternate telescope technology for several years, which ESA now feels can meet Herschel requirements; therefore, continuation of the U.S. telescope activity was not critical to success of the program.*
Herschel Technology Development Plan: FY 2002	Complete the Spectral and Photometric Imaging Receiver (SPIRE) qualification model detectors.
GLAST Prototype Instrument Performance Plan: FY 2000 Actual: FY 2000	The prototype primary instrument for GLAST will demonstrate achievement of the established instrument performance level of angular resolution of 3.5 degrees across the entire 20-MeV (million electron volts) to 100-GeV (giga-electron volts) energy range. *A prototype GLAST instrument was constructed and successfully operated in a beam test in December 1999/ January 2000. Analysis of this data and comparison with detailed computer simulations demonstrate performance as expected. [However, the metric as stated is in error. It should read "less than 3.5 degrees at 100-MeV;" The detector was not tested at 20-MeV. (Reference GLAST AO 99-OSS-03, table 1).]*
GLAST Technology Development Plan: FY 2001	Conduct successful NAR for instrument development, project definition, and interface development.
GLAST Technology Development Plan: FY 2002	Conduct Large-Area Telescope Preliminary Design Review (PDR).

New Millennium Program

ST-5 Critical Design Review Plan: FY 2001 Revised: FY 2002	Complete ST-5 Critical Design Review. *Delayed due to difficulty in securing secondary launch vehicle.*
ST-6, ST-7, and ST-8 Project Selections Plan: FY 2001 Actual: January 2001	Competitively select two-to-three subsystem technology demonstrations. *Eight subsystem technologies have been competitively selected for Phase A study.*
ST-6 and ST-7 Project Approval Plan: FY 2001	Complete ST-6 and ST-7 project approval.
ST-6 Confirmation Review Plan: FY 2002	Conduct ST-6 Confirmation Review.
ST-6 Critical Design Review Plan: FY 2001 Revised: FY 2002	Complete ST-6 Critical Design Review (CDR). *The metric for ST-6 Project Approval (above) was established in the FY 2001 narratives. This CDR metric, also listed in the FY 2001 narratives, was an error; project approval and CDR would not have been planned for the same fiscal year.*
New Millennium Carrier-1 (NMC-1) Confirmation Review Plan: FY 2002	Conduct New Millennium Carrier-1 (NMC-1) Confirmation Review.

ACCOMPLISHMENTS AND PLANS

Core Program

The Information Systems program will continue to provide reliable access for research communities and the public to obtain science data through the National Space Science Data Center and other discipline-oriented data centers. Continuing advances in development and infusion of evolving information technology will increase the level of interoperability to support interdisciplinary research.

The Intelligent Systems program completed a Non-Advocate Review (NAR) in FY 2001. The program has been transferred to Aero-Space Technology Enterprise in FY 2001 and beyond.

In High Performance Computing and Communication, the Remote Exploration and Experimentation project will support the development of a first-generation testbed for scaleable spaceborne applications as well as embedded scaleable high-performance computers. Funding for this activity is ending in FY 2001 as a result of policy and budget prioritization decisions.
Science instrument development will continue to develop initial technologies for new sensors, detectors, and other instruments in support of specific space science research objectives. In many cases these technologies will be flown and validated as part of the suborbital program, either on balloons or rockets.

Planetary Flight Support will continue to develop the Advanced Multi-Mission Operations System ground system upgrade, which will enable greater efficiency in the monitoring of spacecraft systems. This improved efficiency will allow us to continue to reduce mission operations costs.

A competitive NASA Research Announcement (NRA) will be released in FY 2002 to provide for full participation of industry, academia and other government agencies in key In-Space Propulsion technology activities.

In FY 2000 the Decadal Planning Team (DPT) refined the integrated human and robotic strategy for achieving the new science and discovery grand challenges. Work included conducting technology feasibility assessments; conducting systems and architectures analyses of stepping stone capabilities; developing technology roadmaps and attendant gap analyses to meet the stepping stone capabilities; and assessing the benefits to both the Agency and non-Agency programs from investment in DPT technologies.

In FY 2001, the DPT is proceeding to develop the requirements to guide the Agency's technology investment priorities and initiate technology development by leveraging several existing Agency technology programs. Work will continue on high-priority tasks in system and architecture analyses and technology roadmapping, particularly in-space transportation. These tasks are necessary to define decision criteria for future decision-makers on major Agency human and robotic investments.

In FY 2002, the DPT plans to begin implementation of technology development for the highest priority technologies including in-space transportation, bioastronautics, materials research, and other approved technology areas.

The Cross Enterprise Technology Development Program (CETDP) NASA Research Announcement (NRA) was released during the first quarter of FY 2000. Following the peer-reviewed competition, 111 technologies were selected for award, out of 1229 proposals. In FY 2001 Crosscutting Technology has been transferred to Aero-Space Technology Enterprise.

<u>Focused Programs</u>

The **Astronomical Search for Origins** focused program will fund mission design and technology development for six elements in FY 2001 and 2002:

- An interferometry technology validation flight, StarLight (formerly ST-3), to demonstrate the concept of separated-spacecraft interferometry. StarLight will utilize two spacecraft to validate precision formation flying and space interferometry, technologies that are required for the Terrestrial Planet Finder (TPF) mission (see below).

- The Space Interferometry Mission (SIM) will be the world's first long-baseline operational optical space interferometer. It is scheduled for launch late this decade, assuming successful technology development. This mission has dual objectives: science and technology. The science objectives include: astrometric detection of planets around other stars in our galaxy (mostly those of Uranus' mass but also some as small as several Earth masses); and precision location of very dim stars to an unprecedented accuracy (SIM will be a factor of 250 better in accuracy on stars 1000-times fainter than the best catalog currently available). The technology objective is to serve as the precursor to the future interferometry-based TPF mission. Specific technologies to be developed include precision laser metrology, controlled optics, optical delay lines, vibration isolation and structural quieting systems, and deployable structures.

- The Next Generation Space Telescope (NGST) will combine large aperture and low temperature in an ideal infrared observing environment. NGST will allow astronomers to study the first protogalaxies, the first star clusters as they make their first generation of stars, and the first supernovae as they release heavy chemical elements into the interstellar gas. New technologies include: precision-deployable structures; very large, low-area-density, cold mirrors and active optics; and low-noise, large-format infrared detectors. The target launch date is late this decade, also assuming successful technology development.

- Keck Interferometer Phase 1 enables NASA to capitalize on its significant previous investment in the Keck Observatory in Hawaii by connecting Keck's twin 10-meter telescopes into an 85-meter-baseline interferometer. When Phase 1 is completed, the Keck interferometer will become the world's most powerful ground-based optical instrument. Keck will be able to directly detect hot planets with Jupiter-size masses and will also be able to characterize clouds of dust and gases permeating other planetary systems. Phase 2 will add four 1.8-meter outrigger telescopes to the interferometer complement which will allow astrometric detection of Uranus-sized planets and will provide the capability to image protoplanetary discs.

- Terrestrial Planet Finder (TPF) is aimed at the ultimate goal of the NASA's Origins program: to find Earth-like planets. Each of the precursor Origins activities, including the Space Infrared Telescope Facility (SIRTF), provides knowledge and technology needed for the design of the TPF. As currently envisioned, TPF will either be a large single-spacecraft interferometer or a group of several spacecraft (possibly copies of NGST) flown in precise formation. Thus, the experience and understanding gained in each step of the Origins program will be needed to make TPF successful. TPF is currently planned for launch early next decade.

- The Optical Interferometry Laboratory at the Jet Propulsion Lab will enable the development and verification of interferometry systems operating at the extremely high levels of precision required to meet the objectives of the Origins program. The new facility will include a high bay, a low bay, a ground support equipment room and three development laboratories.

The **Solar System Exploration** focused program (previously called Deep Space Systems Development) will continue to provide for the development, integration, and testing of revolutionary technologies and missions for the Outer Planets Program (OPP). The funding identified for the Solar System Exploration focused program supports Europa Orbiter and technologies aimed at future OPP missions.

- Europa Orbiter (EO) will study Jupiter's fourth largest moon, Europa, which has attracted immense interest because of indications that a liquid ocean may lay underneath its icy crust. The EO mission is to confirm the existence of a subsurface ocean and study its characteristics. The EO mission will complete its grass-root cost analysis by March 2001 and complete its Independent Assessment (IA) by 4th quarter FY 2001. EO Phase 1 avionics hardware will be delivered by FY 2002.

- Technology development to be funded within the Solar Systems Exploration focused program will support the OPP missions (i.e., EO and other potential OPP missions). Technologies in this line may include Advanced Radioisotope Power Source (RPS), Center for Integrated Space Microsystems (CISM), and other Exploration Technologies. These technologies are currently under a Zero-Based Budget review to determine their feasibility and their applications to the OPP. The zero-based budget review will be completed by the 3rd quarter of FY 2001, and a plan for the content of the FY 2002 technology program will be announced at that time.

The focus for **Sun-Earth Connections** mission planning and technology activities, including both the Solar-Terrestrial Probes and Living With a Star programs, will be directed toward the following future missions:

- Solar-B is a joint mission with the Japanese (ISAS spacecraft and launch). NASA is to provide optical, EUV, and X-ray instrument components for the ISAS-led mission to measure the Sun's magnetic field and UV/X-ray radiation. Funding for this project moved to the Payload and Instrument Development program in FY 2001 (see page SAT 1-XX above).

- STEREO is a mission to understand the origin of mass ejections from the Sun's corona and their consequences, including intense solar energetic particle events. The mission is conceived as two spacecraft in solar orbit that provide stereo imaging of solar corona, track solar mass ejections from the Sun to the Earth using radio and optical instruments, and measure the solar wind and energetic particles. STEREO's anticipated launch date is December 2004. Funding for STEREO is broken out separately as a major development project, beginning in FY 2002 when the project is scheduled to begin implementation (see page SAT 1-XX above).

- Magnetospheric Multiscale is a mission with four spacecraft in elliptical orbits around the Earth to study the interaction of the solar wind with the Earth's magnetosphere. Its launch is planned in 2007.

- Global Electrodynamics Connection is a mission with four Earth-orbiting and dipping spacecraft that will investigate the transition region between the magnetosphere and dense atmosphere, the area that may be important in the Earth's electric field circuit. It is a region where there is a continual tug-of-war between magnetosphere- and lower atmosphere-driven dynamics. Its launch is planned in 2008.

- Magnetospheric Constellation is a network of 10-100 nanosats in Earth orbit to investigate the plasma and fields in the Earth's magnetotail and the linkage between the plasma and fields and the solar wind. Its target launch date is 2010.

- Solar Dynamics Observatory (SDO), a follow-on to Yohkoh, will observe the Sun's dynamics to help us understand the nature and source of the Sun's variations, from the stellar core to the turbulent solar atmosphere. Its launch is planned in late 2006.

- The Radiation Belt Mapper and Ionospheric Mapper missions will provide a network of measurements around the Earth to increase our understanding of origin and dynamics of the radiation belts and ionosphere, thereby increasing our understanding of how the Earth responds to solar variability. The target launch dates are 2009.

- The Solar Sentinel missions will provide a global view of the heliosphere and describe the transition and evolution of eruptions and flares from the Sun to Earth. The target launch dates are 2008 and 2009.

Structure and Evolution of the Universe mission planning and technology activities focus on development and demonstration of technologies necessary to implement the space missions outlined in the recent SEU Science and Technology Roadmaps. The priority missions include:

- Gamma Ray Large Area Space Telescope (GLAST). GLAST will study cosmic sources of high-energy particles and radiation (up to 300 GeV) with a large area, wide field-of-view, imaging telescope, using solid-state particle tracking technology. This technology is being developed in cooperation with DoE. Funding for GLAST is broken out separately, as a major development project, beginning in FY 2002, when the project is scheduled to begin implementation (see page SAT 1-22 above).

- On the 200th anniversary of the discovery of infrared light by William Herschel, ESA's Far Infrared and Submillimeter Space Telescope (FIRST) was re-named Herschel Space Observatory. The U.S. participation on the Herschel mission substantially enhances the science goals with four key technologies: cryocoolers, bolometer arrays, and heterodyne receivers. U.S. participation in the development of the mission will be limited to instruments, as U.S. funding is limited, and ESA has technologies available to meet the telescope requirements. Funding for Herschel is included in the Payload and Instrument Development budget beginning in FY 2002 (see page SAT 1-24 above).

- Constellation X-ray Mission. Constellation-X will use multiple satellites to enable a very large collecting area. Each spacecraft will be equipped with a high-throughput telescope for the low-energy band up to 10 keV, and three grazing-incidence telescopes for the high-energy band. Technology funding will support decisions on future mission development.

- Laser Interferometer Space Antenna (LISA). LISA will be a joint NASA-ESA mission to detect and study gravitational wave signals from massive black holes. This includes both transient signals from the terminal stages of binary coalescence (bursts) and binary signals that are continuous over the observation period. Technology funding will support decisions on future mission development.

New Millennium

A constellation of three small satellites called the Nanosat Constellation Trailblazer mission was selected in August 1999 as the Space Technology-5 (ST-5) demonstrator. Each Trailblazer spacecraft will be an octagon 16 inches across and 8 inches high, and each will have booms and antennas that will extend after launch. Results from the Trailblazer mission will be used to design future missions using constellations of lightweight (about 44 pounds), highly miniaturized autonomous spacecraft During fiscal year 2000, ST-5 completed both their mission requirements and system concepts reviews. Confirmation Review will take place in fiscal year 2001, followed by development in fiscal year 2002.

A Technology Announcement for the Space Technology-6 (ST-6) subsystem technology validation opportunity was issued in October 2000. Eight technologies ranging from revolutionary low-power electronics to a continuously operating helium dilution cooler were competitively selected in January 2001 for concept development (Phase A study). ST-6 down-selection is planned for late FY 2001/early FY 2002, where it is anticipated that three to five of the technologies will be competitively selected for ST-6 flight validation in calendar years 2003 and 2004. Pre-concept definition studies for Space Technology-7 (ST-7), a small system validation opportunity, were initiated in January 2001. NASA plans to solicit and competitively select technologies for ST-7 concept definition during FY 2001. Feasibility studies (pre-phase A) were initiated for the New Millennium Carrier (NMC)-1 Space Technology Carrier (STC) in FY 2001 to explore access-to-space options for stand-alone subsystem technology validation.

BASIS OF FY 2002 FUNDING REQUIREMENT

RESEARCH PROGRAM

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Research Program	567,450	596,773	606,500
Research and Analysis	239,450	244,661	246,200
Data Analysis	291,100	310,504	319,200
Suborbital	36,900	41,608	41,100
Balloon Program	13,300	15,266	14,000
Sounding Rockets	23,600	26,342	27,100

PROGRAM GOALS

The goals of the Space Science Research and Analysis Program are: (1) to enhance the value of current space missions by carrying out supporting ground-based observations and laboratory experiments; (2) to conduct the basic research necessary to understand observed phenomena, and develop theories to explain observed phenomena and predict new ones; and, (3) to continue the analysis and evaluation of data from laboratories, airborne observatories, balloons, rocket experiments and spacecraft data archives. In addition to supporting basic and experimental astrophysics, space physics, and solar system exploration research for future flight missions, the program also develops and promotes scientific and technological expertise in the U.S. scientific community.

The goal of the Space Science Data Analysis program is to maximize the scientific return from our space missions, within available funding. The Data Analysis program is the source of the enormous scientific return generated from our investments in space hardware. Besides scientific advancements, the Data Analysis program also contributes to public education and understanding through media attention and our own education and outreach activities.

The principal goal of the Suborbital program is to provide frequent, low-cost flight opportunities for space science researchers to fly payloads to conduct research of the Earth's ionosphere and magnetosphere, space plasma physics, astronomy, and high-energy astrophysics. The program also serves as a technology testbed for instruments that may ultimately fly on orbital spacecraft, thus reducing cost and technical risks associated with the development of future space science missions. It is also the primary opportunity for training graduate students and young scientists in hands-on space flight research techniques.

STRATEGY FOR ACHIEVING GOALS

RESEARCH AND ANALYSIS

The Space Science Research and Analysis Program carries out its goals and objectives by providing grants to non-NASA research institutions throughout the Nation and the world, as well as by funding scientists at NASA Field Centers. Approximately 1,500 grants are awarded each year after a rigorous peer-review process; only about one out of four proposals is accepted for funding, making this research program among the most competitive in government. This scientific research is the foundation of the Space Science Enterprise. Key research activities include the analysis and interpretation of results from current and past missions; synthesis of these analyses with related airborne, suborbital, and ground-based observations; and the development of theory, which yields the scientific questions to motivate subsequent missions. The Research and Analysis Program also develops new types of detectors and other scientific instruments. Many of these new instrument concepts are tested and flown aboard sounding rockets or balloons. The publication and dissemination of the results of new missions to scientists and the world is another key element of the Research and Analysis Program strategy, since it both inspires and enables cutting-edge research into the fundamental questions that form the core of the mission of the Space Science Enterprise. Currently, with the exception of a proprietary period of up to one year for some missions, 100% percent of the data from current and past Space Science missions is openly available to the public via the internet. In the future, these proprietary periods will be phased out completely.

The Enterprise NRA for Research Opportunities in Space Science (ROSS) solicits proposals for basic investigations to seek to understand natural space phenomena across the full range of space science programs relevant to the four OSS science themes. Participation in this program is open to all categories of U.S. and non-U.S. organizations including educational institutions, industry, nonprofit institutions, NASA Centers, and other Government agencies. Minority and disadvantaged institutions are particularly encouraged to apply. Recommendations for funding are based on the independent evaluation of each proposal's science and technical merits, and its relevance to the Space Science Enterprise objectives as described in the NRA.

DATA ANALYSIS

The Space Science Data Analysis program supports scientific teams using data from our spacecraft. Depending on the mission, scientists supported may include Principal Investigators who have built hardware and been guaranteed participation, Guest Observers who have successfully competed for observing time, and researchers using archived data from current or past missions. Data Analysis funding also supports a number of critical "Science Center" functions that are necessary to the operation of the spacecraft but do not involve the actual commanding of the spacecraft. For instance, the planning and scheduling of spacecraft observations, the distribution of data to investigators, and data archiving services are all supported under Data Analysis.

SUBORBITAL

The Suborbital program provides the science community with a variety of options for the acquisition of in-situ or remote sensing data. Aircraft, balloons and sounding rockets provide access to the upper limits of the Earth's atmosphere. Activities are conducted on both a national and international cooperative basis.

Balloons provide a cost-effective way to test flight instrumentation in the space radiation environment and to make observations at altitudes above most of the water vapor in the atmosphere. In many instances, it is necessary to fly primary scientific experiments on balloons, due to size, weight or cost considerations, or to the lack of other opportunities. Balloon experiments are particularly useful for infrared, gamma-ray, and cosmic-ray astronomy. In addition to the level-of-effort science observations, the program has successfully developed balloons capable of lifting payloads greater than 5000 pounds. Balloons are now also capable of conducting a limited number of missions lasting 9 to 24 days, and successful long-duration flights are being conducted in or near both polar regions. The GSFC Wallops Flight Facility (WFF) manages the Balloon contract. The National Scientific Balloon Facility (NSBF), a government-owned, contractor-operated facility in Palestine, Texas, conducts flight operations.

Analytical tools have been developed to predict balloon performance and flight conditions. These tools are being employed to analyze new balloon materials in order to develop an ultra-long-duration balloon (ULDB) flight capability (approximately 100 days), based on super-pressure balloons. An integrated management team has been established to develop and test the balloon vehicle and balloon-craft support system.

Sounding rockets are uniquely suited to perform low-altitude measurements (between balloon and spacecraft altitude) and to measure vertical variations of many atmospheric parameters. Sounding rockets are used to support special areas of study, such as: the nature, characteristics and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including aurora production and energy coupling into the atmosphere; and the nature, characteristics and spectra of radiation of the Sun, stars and other celestial objects. In addition, sounding rockets allow several science disciplines to flight-test instruments and experiments being developed for future space missions. The program also provides a means for calibrating flight instruments and obtaining vertical atmospheric profiles to complement data obtained from orbiting spacecraft. Launch operations are conducted from facilities at WFF, Virginia; White Sands, New Mexico; and Poker Flat, Alaska, as well as occasional foreign locations. A performance-based contract was awarded February 1999 to allow the government to transition away from operational control. The contract is managed by the GSFC/WFF.

SCHEDULE & OUTPUTS

Space Science Research and Analysis

Issue FY 2000 NASA Research Announcement (NRA) Plan: February 2000 Actual: February 2000	Issue FY 2000 NRA for Research Opportunities in Space Science (ROSS). *The AO was released on February 9, 2000, and is publicly available at http://spacescience.nasa.gov/research/closed00.htm.*
Issue FY 2001 NASA Research Announcement (NRA) Plan: 2nd Qtr., FY 2001 Actual: 2nd Qtr, FY 2001	Issue FY 2001 NRA for Research Opportunities in Space Science (ROSS). *The AO was released on January 26, 2001, and is publicly available at http://spacescience.nasa.gov/research*

Astrobiology Research Plan: FY 2001	High-priority studies identified in the Astrobiology Roadmap will be carried out, the National Astrobiology Institute will conduct institute-wide functions using internet/video conferencing capabilities (i.e. Executive council meetings, science seminars, group collaborations, education/outreach), and Institute research publications will reflect its interdisciplinary nature.

<u>Suborbital Program</u>

Balloon Program

Balloon Flights Plan: FY 2000 Actual: (N/A)	Plans call for 26 worldwide balloon missions. *Twenty-one missions were flown in FY 2000, including two balloons that failed to achieve their required altitude and distance. For two of the missions that did achieve required altitude and distance, investigators' instrumentation failed to function as planned. It should be noted that one of the balloons that failed to reach required altitude was a test flight of a new balloon development. The result was re-design and development of the balloon, which was successfully tested in FY 2001.*
Balloon Flights Plan: FY 2001	Achieve launch success rate of 80% for balloon flights.

Sounding Rockets

Sounding Rocket Flights Plan: FY 2000 Actual: (N/A)	Plans call for 25 worldwide sounding rocket missions. *The increased programmatic costs of the privatization of sounding rocket operations in FY 1999 were not reflected in the FY 2000 budget. Seven sounding rocket missions were moved out of FY 2000 into later years, leaving a goal of 18 planned missions for the year. Sixteen missions were launched, including two failures to achieve the required altitude and orientation. Two other missions failed to meet their minimum success criteria.*
Sounding Rocket Flights Plan: FY 2001	Achieve launch success rate of 80% for sounding rocket flights.

ACCOMPLISHMENTS AND PLANS

Research and Analysis

Our R&A program continued to produce exciting scientific results in 2000. The program supported many of the recent discoveries of planets around other stars. Particularly exciting was the discovery of increasing numbers of planets with masses equivalent to one Jupiter or less. By the end of 2000, the number of known planets around other stars reached over 50. While the potential detection of Earth-like planets remains in the future, per our plans for the Origins program, these R&A-funded results increase the likelihood that such planets may be common in the universe, and are already leading to advances in theoretical models of planetary system formation.

The Near-Earth Object (NEO) Program Office at JPL continues to focus on the goal of locating at least 90 percent of the asteroids and comets that approach the Earth and are larger than about 2/3-mile (about 1 kilometer) in diameter, by the end of the next decade. These are objects that are difficult to detect because of their relatively small size, but are large enough to cause global effects if one were to hit the Earth. Detection, tracking, and characterization of such objects are all critical. As additional telescopes and improved detectors have been added to the search, the detection rate has continued to increase. Current estimates (based on a statistical analysis of the objects located to date) are that approximately half of the NEO's have been located.

In recognition of the interrelationship between the origin and evolution of life and the origin and evolution of planets, a new program within the framework of Astrobiology was initiated in 1997. A multi-disciplinary Astrobiology Institute was established with members from 11 geographically distributed research institutions, linked through advanced telecommunications. Examples of research accomplishments for the past year include a genetic study demonstrating that the ancestors of major groups of animal species may have begun populating Earth 1.2 billion years ago, more than 600 million years earlier than indicated by their fossil remains. It was demonstrated that methanogenic bacteria could grow in conditions simulating the subsurface of Mars if even a small amount of water is available. And a microbial world was discovered hidden deep beneath the frozen Antarctic ice; this could help us learn more about how life can survive under extreme conditions on other planets or moons.

Data Analysis

NASA's Space Science spacecraft continue to generate a stream of scientific discoveries. Many of these findings are of broad interest to the general public, as demonstrated by widespread media coverage. Recent highlights include results from Hubble Space Telescope, the Chandra X-ray Observatory, the Near Earth Asteroid Rendezvous (NEAR), Mars Global Surveyor, Cassini, Galileo, Transition Region and Coronal Explorer (TRACE), and the Solar and Heliospheric Observatory (SOHO). However, many other Space Science spacecraft have been "in the news" and extremely scientifically productive as well. NASA is also finding ways to partner with the education community in order to strengthen science, technology, and mathematics education. Listed below are just a few of the top science stories of the past year from NASA Space Science missions.

- Imaging scientists using data from Mars Global Surveyor found features that suggest there may be current sources of liquid water at or near the surface of the Red Planet. If verified, this finding clearly increases the possibility that life may still exist on Mars. The finding would also be important for the planning of future human missions to the Red Planet.

- A week's advance warning of potential bad weather in space is now possible thanks to the Solar and Heliospheric Observatory (SOHO) spacecraft. SOHO scientists have, for the first time, imaged solar storm regions on the side of the Sun facing away from the Earth.

- Layers of sedimentary rock paint a portrait of an ancient Mars that long ago may have featured numerous lakes and shallow seas, say Mars Global Surveyor imaging scientists.

- Giant fountains of fast-moving, multimillion-degree gas in the outermost atmosphere of the Sun have revealed an important clue to a long-standing mystery -- the location of the heating mechanism that makes the corona 300 times hotter than the Sun's visible surface. These results came from TRACE.

- Scientists used Chandra to examine a mid-mass black hole in the galaxy M82. This black hole may represent the missing link between smaller stellar black holes and the supermassive variety found at the centers of galaxies.

- A HST census finds that the mass of a supermassive black hole is directly related to the size of a galaxy’s nuclear bulge of stars. This suggests that the evolution of galaxies and their host black holes is intimately linked, and has implications for the history of the very early Universe.

Suborbital Program

In FY 2000, 21 balloons were flown for the core program, of which 17 were successful flights. The balloon-borne BOOMERANG sub-millimeter telescope mapped the faint light left over from the Big Bang, revealing the earliest structure in the Universe that billions of years later would become the vast clusters of galaxies that astronomers observe today. We now can confirm that the Universe is flat (Euclidean) and that space is accelerating. Capping years of technology development, the long duration ballooning (LDB) capability has been repeatedly demonstrated and is now fully operational. Work is underway to demonstrate an ultra-long duration capability in 2001. Collaboration work with JPL is focusing on ULDB technologies that could be useful for planetary exploration programs on other worlds such as Mars or Venus.

In FY 2000 19 sounding rocket missions were flown, of which 16 were successful flights. The sounding rockets included determination of the ionospheric effects of lightning strokes, the validation of new soft-x-ray measurement techniques and vital SOHO mission support. In FY 2001 expected accomplishments include high-resolution studies of atmospheric gravity waves, calibration of the TIMED satellite by flying under it, and a multi-rocket study of the upper atmosphere enabled by the development of new, small Viper Dart rockets.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE SCIENCE INVESTMENTS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Enterprise Contribution to Academic Programs	10,200	13,200	
Education Program		1,500	
Minority University Research and Education Program	10,200	11,700	
Total	10,200	13,200	

* In FY 2002, Space Science for academic programs is transferred to Academic Programs as an agency-wide consolidation of funding in academic programs. Detailed FY 2002 information can be found in the *Academic Programs* section.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE SCIENCE INSTITUTIONAL SUPPORT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Institutional Support to Space Science Enterprise.......... ..	[330,369]	[303,675]	333,362
Research and Program Management	[310,482]	[282,347]	311,914
Personnel and Related Costs............. ..	[238,848]	[227,165]	243,324
Travel	[6,967]	[5,914]	6,331
Research Operations Support............. .	[64,667]	[49,268]	62,259
Construction of Facilities	[19,887]	[21,328]	21,448
Full-Time Equivalent (FTE) Workyears	**[2,362]**	**[2,173]**	**2,187**

Note - FY 2000 and FY 2001 data in this section are for comparison purposes only. See *Mission Support* sections for more details.

The Space Science budget contains funding for civil servants at Goddard Space Flight Center, Ames Research Center, Langley Research Center, Marshall Space Flight Center, Johnson Space Center, and Headquarters. Jet Propulsion Laboratory is a Federally Funded Research and Development Center; therefore, the Lab's employees are not civil servants, and their personnel and related costs are included in direct program costs.

Goddard Space Flight Center (GSFC)

The Office of Space Science provides approximately 49% of GSFC's institutional funding. GSFC personnel manage physics and astronomy activities in the following discipline areas: gamma ray astronomy, X-ray astronomy, ultraviolet and optical astronomy, infrared and radio astronomy, particle astrophysics, solar physics, interplanetary physics, planetary magnetospheres, and astrochemistry. GSFC is also responsible for conducting the mission operations for a variety of operating spacecraft. Other activities include managing NASA's sounding rocket and scientific balloon program.

GSFC personnel also conduct planetary exploration research into the physics of interplanetary and planetary space environments, and they participate in planetary mission instrument development, operations, and data analysis. In addition, GSFC FTEs develop technologies targeted at improved spaceborne instruments, and on-board spacecraft systems and subsystems.

Ames Research Center (ARC)

The Office of Space Science provides approximately 13% of ARC's institutional funding. Ames Research Center has the agency lead role in Astrobiology (the study of life in the universe), which focuses on the origin of life and its possible development on other worlds. R&PM funding covers planetary atmosphere modeling, including relationships to the atmosphere of the Earth; research into the formation of stars and planetary systems; and an infrared technology program to investigate the nature and evolution of astronomical systems. Development continues of the Stratospheric Observatory for Infrared Astronomy (SOFIA) for research to be conducted by various NASA/university teams. Research and development in advanced information technologies are directed toward significantly increasing the efficiency of SOFIA as it becomes operational.

Langley Research Center (LaRC)

The Office of Space Science provides approximately 4% of LaRC's institutional funding. Langley Research Center personnel support the solicitation and selection process of the Office of Space Science's (OSS) Discovery, Explorer and Solar Terrestrial Probes Programs. They also conduct reviews of candidate and selected missions and independent assessments of on-going Space Science missions to help ensure that OSS criteria for high quality science return within cost and schedule constraints are met. LaRC technologists will conduct a technology development program that develops advanced ultra-lightweight and adaptive materials, structural systems technologies and analytical tools for significantly reducing the end-to-end cost and increasing the performance of space science instruments and systems. Langley is developing the SABER instrument, which is on the TIMED mission to explore the mesosphere and lower thermosphere. Langley scientists are also analyzing SAMPEX data to assess the relative importance of solar terrestrial coupling due to varying electron precipitation compared to that due to 11-year solar flux variations. Langley has provided and continues to provide analysis of spacecraft aerodynamics, aerothermodynamics and flight dynamics for spacecraft entering planetary atmospheres (including Earth) in support of both spacecraft design and flight operations.

Marshall Space Flight Center (MSFC)

The Office of Space Science provides approximately 7% of MSFC's institutional funding. MSFC was the NASA lead center for Chandra X-ray Observatory development and, following Chandra's successful launch and deployment on July 23, 1999, MSFC continues to lead the on-orbit science operations phase. MSFC personnel will also continue leading the Relativity Mission (Gravity Probe-B) and will continue to manage other selected payloads. Leading the Agency in Space Optics Manufacturing and Technology, MSFC technologists will develop ultra lightweight large-aperture optics and optical technology for space applications, provide world class facilities and capabilities for optics fabrication, metrology, and undertake tests that will benefit NASA, other government agencies, academia, and industry.

Johnson Space Center (JSC)

The Office of Space Science provides approximately 2% of JSC's institutional funding. The Johnson Space Center (JSC) scientists support the Agency's planetary science program in the area of geosciences required to support future programs, provide curatorial support for lunar materials, assist in information dissemination, and interact with outside scientists. Their research focuses on the composition, structures, and evolutionary histories of the solid bodies of the universe.

Headquarters (HQ)

The Office of Space Science provides approximately 2% of HQ's institutional funding. The Enterprise's Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTE's across the agency. A more complete description can be found in the Mission Support/two Appropriation budget section.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF BIOLOGICAL AND PHYSICAL RESEARCH — **BIOLOGICAL AND PHYSICAL RESEARCH**

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Advanced Human Support Technology (AHST)	30,094	30,832	31,100	SAT 2-7
Biomedical Research & Countermeasures (BR&C)	57,167	70,206	66,792	SAT 2-10
[Construction of facilities]	[9,000]	[8,581]	[9,800]	
Fundamental Space Biology (FSB) (Formerly Fundamental Biology (FB))..............	38,180	40,610	39,200	SAT 2-13
Physical Sciences Research (PSR) (Formerly Microgravity Research (MR))	108,745	130,659	130,087	SAT 2-15
Space Product Development (SPD)	14,400	13,683	14,508	SAT 2-20
Health Research (HR) (Formerly Occupational Health Research (OHR) and Space Medicine Research (SMR))..........	8,700	11,714	9,400	SAT 2-22
Mission Integration (MI)	17,414	15,206	213	SAT 2-25
[Life Sciences Research Facility at the University of Missouri]	[12,814]	[14,967]		
Investments and Institutional Support (MUREP from BR&C in FY 2000 and in FY 2001)	[65,518]	[65,859]	69,620	SAT 2-27
Total...	274,700	312,910	360,920	

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET
	(Thousands of Dollars)		
Distribution of Program Amount by Installation			
Johnson Space Center (JSC)	106,822	124,215	120,888
Kennedy Space Center (KSC)	6,752	5,349	7,678
Marshall Space Flight Center (MSFC)	48,498	58,713	87,775
Ames Research Center (ARC)	32,767	49,875	48,344
Langley Research Center (LaRC)	52	35	269
Glenn Research Center (GRC)	39,397	36,917	49,883
Goddard Space Flight Center (GSFC)	11,757	4,317	2,087
Jet Propulsion Laboratory (JPL)	10,793	14,706	13,587
Headquarters (HQ)	17,862	18,783	30,410
Total	274,700	312,910	360,920

GENERAL

The Office of Biological and Physical Research (OBPR) was created at the beginning of FY 2001 to affirm NASA's commitment to the essential role biology will play in the 21st century, to establish the core of biological and physical sciences research needed to support Agency strategic objectives, and to ensure an effective management structure to optimize implementation of the Agency's scientific and technological goals in conjunction with internal NASA organizations and other external Agencies and organizations. OBPR assumes an independent role as NASA's fourth research organization and fifth strategic enterprise along with the offices of Space Science, Earth Science, Aerospace Technology, and Space Flight. OBPR was created by restructuring the Office of Life and Microgravity Sciences and Applications (OLMSA) under the premise that revolutionary solutions to science and technology problems are likely to emerge from scientists, clinicians, and engineers who are working at the frontiers of their respective disciplines and are also engaged in dynamic interdisciplinary interactions. OBPR will foster and enhance rigorous interdisciplinary research, closely linking fundamental biological and physical sciences in order to develop leading-edge, world-class research programs. OBPR is dedicated to using the unique characteristics of the space environment to understand biological, physical, and chemical processes, conducting science and technology research required to enable humans to safely and effectively live and work in space, and transferring knowledge and technologies for Earth benefits. OBPR also fosters commercial space research by the private sector towards new or improved products and/or services on Earth, in support of the Agency's mandate to encourage the commercial use of space. Information about OBPR may be accessed at its web site (http://spaceresearch.nasa.gov/). NASA plans to transition management of the ISS Research Budget to OBPR in a phased approach. Commencing in FY 2002, budget execution responsibility will be transferred from the Office of Space Flight to OBPR. In FY 2003, budget formulation and budget execution responsibility will be transferred to OBPR.

PROGRAM GOALS

The Office of Biological and Physical Research asks questions that are basic to the future of humanity: (1) How do fundamental laws of nature shape the evolution of life?; and (2) How can human existence expand beyond the home planet to achieve maximum benefits from space? The Office pursues the answers to these questions by: (1) using the space environment as a laboratory to test the fundamental principles of physics, chemistry and biology; (2) conducting research to enable the safe and productive human habitation of space; and (3) enabling and promoting commercial research in space for the benefit of life on Earth.

OBPR plays a primary role in the pursuit of the following Agency goals and objectives as outlined in the NASA Strategic Plan:

Goal: Conduct research to enable safe and productive human habitation of space.

Objective- Conduct research to ensure the health, safety, and performance of humans living and working in space.

Objective- Conduct physical science research on planetary environments to ensure safe and effective missions of exploration.

Objective- Conduct research on biological and physical processes to enable future missions of exploration.

Goal: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

Objective- Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

Objective- Develop strategies to maximize scientific research output on the International Space Station (ISS) and other space research platforms.

Goal: Enable and promote commercial research in space.

Objective- Provide technical support for companies to begin space research.
Objective- Ensure that NASA policies facilitate industry involvement in commercial space research.

Objective- Systematically provide basic research knowledge to industry.

Objective- Foster commercial research endeavors with the International Space Station and other assets.

Goal: Use space research opportunities to improve academic achievement and the quality of life.

Objective- Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.
Objective- Engage and involve the public in research in space.

STRATEGY FOR ACHIEVING GOALS

OBPR pursues the goals described above through conducting activities in conjunction with four other major Federal Agencies (the National Institutes of Health; the National Science Foundation; the Department of Defense, including the Defense Advanced Research Projects Agency, the United States Air Force, the Office of Naval Research, and other DOD organizations; and the Department of Energy) through approximately 40 partner agreements. OBPR has recently initiated collaboration with the National Cancer Institute on revolutionary approaches to detecting and diagnosing in-vivo the onset of molecular anomalies related to disease or to space-flight-induced physiological degeneration, establishing the relevance of space-based endeavors to Earth-bound health issues. A joint solicitation for research in Fundamental Technologies for the Development of Biomolecular Sensors between NASA and the National Cancer Institute was released in FY 2001, with selections planned for FY 2002. These Biomolecular Physics and Chemistry projects will be managed at the Ames Research Center. In addition, OBPR manages 11 Commercial Space Centers across the country.

OBPR's major program areas, which focus on specific fields of research are:

Bioastronautics Research (BR) (includes AHST & BR&C)

- Set priorities for issues relating to flight crew health and medical technology, and drive priorities for fundamental and applied research to mitigate risk to crew health, safety, and performance.
- Sponsor research to develop therapeutics, procedures, techniques, and equipment needed to address flight medical, safety, and performance issues.
- Integrate science and medical research to generate the knowledge required to enable flight crews to leave low-Earth orbit, perform their assigned tasks, and return to Earth with their health intact.

Fundamental Space Biology (FSB)

- Use microgravity and the other characteristics of the space environment effectively to enhance our understanding of fundamental biological processes.
- Develop the foundation of fundamental biological knowledge required to enable a long-duration human presence in space.
- Develop the biological understanding to support other NASA activities related to biology.
- Apply this knowledge and technology to improve our Nation's competitiveness, education, and the quality of life on Earth.

Physical Sciences (PS)

- Carry out cutting-edge, peer-reviewed, and multi-disciplinary basic research as enabled by the space environment, to address NASA's goal of advancing and communicating knowledge.
- Develop a rigorous, cross-disciplinary scientific capability, bridging the physical sciences and biology to address NASA's human and robotic space exploration goals.

- Establish the ISS facilities as unique, on-orbit science laboratories addressing targeted scientific and technological issues of high significance.
- Enhance the knowledge base that contributes to Earth-based technological and industrial applications.

OBPR is an operational organization conducting the following functions:

Health Research (HR)
- Space Medicine Research (SMR)
  - Ensure the delivery of clinical care in support of human space flight.
  - Establish requirements for medical care and medical research to support human space flight.
- Occupational Health Research (OHR)
  - Contribute to the health, well-being, safety, and productivity of the NASA workforce.

NASA is in the process of realigning the HR function among the Office of the Chief Health and Medical Officer, the Office of Space Flight, and the Office of Biological and Physical Research. Some realignment of functions and the concomitant budget may occur by FY 2002.

Research Integration (RI) (includes SPD & MI}
- Manage the Commercial Space Centers (CSCs) to foster a robust commercial space research program in diverse fields of biotechnology, materials research, and agriculture.
- Integrate OBPR flight facilities, resources, and operations requirements.
- Integrate flight instruments with platform provider, plan payload manifests, and represent OBPR to the offices of Space Flight, Space Science, and Earth Science.
- Interface with potential non-governmental organization to manage ISS.
- Integrate research missions involving human space flight.
- Integrate ISS increment research missions.

OBPR's program of research and technology development relies upon broad participation by researchers from academia, other government agencies and departments, nonprofit entities, and commercial organizations. In selecting investigations and projects for support, and ultimately for access to space, OBPR follows different, but closely related processes for scientific research, commercial research, and technology research and development.

Non-commercial research is conducted through an open, competitive, peer-reviewed research solicitation process including the regular release of NASA Research Announcements (NRAs) in specific disciplines and reviews of proposals by independent panels of experts. Commercial research initiatives are evaluated against established selection criteria, including leveraged commitment from the private sector, clear product development goals, technical feasibility, and a market assessment.

OBPR supports ground-based research to develop and refine concepts for space experiments and to create a framework of knowledge and expertise in which the full scientific value of the research can be realized. It utilizes the Nation's academic and industrial resources, joining prominent researchers with NASA expertise in multidisciplinary microgravity experimentation. In support of the research community, the program also finances unique gravitational simulation facilities, such as centrifuges, parabolic aircraft, drop towers/tubes, and other specialized support facilities and technologies, such as chambers, bed rest studies, and data archiving.

BASIS OF FY 2002 FUNDING REQUIREMENT

BIOASTRONAUTICS RESEARCH - ADVANCED HUMAN SUPPORT TECHNOLOGY

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Advanced Human Support Technology (AHST)	30,094	30,832	31,100

GOALS

The goals of AHST are: (1) to demonstrate and validate fully self-sufficient technologies for air and water regeneration, food production, and waste recycling for long-duration space missions; (2) to demonstrate and validate integrated, fully autonomous environmental monitoring and control systems; and (3) to validate human factors engineering technology and protocols to ensure maintenance of high ground and flight crew skills during long-duration missions. AHST also makes NASA technologies available to the private sector for Earth applications.

STRATEGY FOR ACHIEVING GOALS

AHST includes Advanced Life Support (ALS), Space Human Factors Engineering (SHFE), and Advanced Environmental Monitoring and Control (AEMC). ALS develops advanced regenerative life support technologies and systems by combining biological, physical, and chemical processes capable of producing and recycling the food, air, and water needed to enable long-term human missions in space in a safe and reliable manner while minimizing the need for resupply. SHFE develops technologies that integrate the human and system elements of space flight, and encourages mission planners to use human factors research results and technology developments to improve mission results and crew safety. AEMC develops advanced control technologies, chemical and biological sensors for air and water monitoring and microbial detection, and also refines and micro-miniaturizes currently available sensors.

Center Support

JSC is the Lead Center for implementing AHST. JSC coordinates all Performing Center activities, manages ALS facilities, and conducts all system-level integration and testing for ALS. KSC manages extramural research and conducts specific research tasks directed at using plants in ALS systems. ARC manages extramural research and conducts specific research tasks directed at analytical models and physicochemical processes for ALS systems. JPL is the lead for the AEMC activities, bringing its personnel and industry contacts to the development of sensors and monitoring and control capability.

ACCOMPLISHMENTS AND PLANS

FY 2000 Accomplishments

Environmental Systems Commercial Space Technology Center: A new Commercial Space Center in the field of Environmental Systems with an emphasis on waste management was awarded to the University of Florida. The Center will perform technology development to advance the area of solid, liquid, and gaseous waste management. The research and technology findings will lead to benefits for NASA's human space flight program, as well as improving waste management practices on Earth.

Life Support Test Bed Development: OBPR (as OLMSA) completed the utilities outfitting for the first phase of the BIO-Plex test bed. BIO-Plex is intended to provide the capability to conduct a series of long-duration, human-in-the-loop, advanced integrated life support technology tests, as well as conduct biomedical, space medicine, and human factors research. BIO-Plex power, external ventilation, emergency monitoring systems, fire detection and suppression systems, and flooring were installed. The ALS and SHFE projects completed the Preliminary Design Review (PDR) for the BIO-Plex Human Accommodations System. Systems analysis of candidate technologies for the first BIO-Plex test was initiated, but due to budget shortfalls in the International Space Station program, activities at the BIO-Plex have been suspended

Miniaturized Quadruple Mass Spectrometer Analyzer for EVA: Development of the mini-mass spectrometer continued at JSC in preparation for space flight in early 2001. The mini-mass spectrometer is capable of detecting minute leaks of ammonia, hydrazine, nitrogen, and oxygen during EVA operation.

"Garden Machine Project" at Texas Tech University (TTU): The "Garden Machine" is a small, environmentally controlled and monitored plant growth chamber, developed by NASA ARC and on loan to TTU by NASA JSC. Progress has been made on performing engineering modifications and upgrades to the chamber for growing salad crops, and plant research is ongoing in anticipation of utilizing the chamber. TTU has also made progress on water recovery research, including the definition of a water recovery field demonstration unit for deployment in Texas colonias.

Future Plans

In FY 2001, AHST will initiate a six-month Advanced Water Recovery System demonstration and continue to demonstrate key technology capabilities for human support, such as advanced techniques for water processing using microbes, a no-expendable trace gas contaminant control system, biomass production, food processing, and solid waste processing. An engineering breadboard/prototype of a Vapor Phase Catalytic Ammonia Removal water recovery subsystem will be developed for integrated evaluation at JSC.

In FY 2002, comprehensive project plan documents for future technology solicitations will be developed for food processing, systems engineering, and advanced controls. External input and guidance in the development of these documents will be solicited from experts around the country via a series of workshops.

A flight test of the Immobilized Microbe Microgravity Water Processing System will be conducted. AHST will continue to demonstrate key technology capabilities for human support, such as advanced techniques for water processing, solid waste processing, air revitalization, biomass production, food processing, and thermal control. NASA JSC and the National Space Biomedical Research Institute (NSBRI) will collaborate in a review of NASA-STD-3000, Man-Systems Integration Standards. NASA-STD-3000 is the Agency-wide document that serves as the basis for human interface requirements for major activities, such as International Space Station.

AHST also will continue to solicit the participation of the university community through the re-competition of an expanded new NASA Specialized Center of Research and Training (NSCORT) in the area of Advanced Life Support.

The AHST NRA will focus on the development of ALS technologies for all aspects of solid waste processing, with special emphasis on storage and water recovery. This will augment the ISS waste stabilization efforts. Additionally, efforts will also be directed toward the development of nutrient delivery systems for plants in a microgravity environment. Work in the AEMC area will continue in the area of high-risk pilot studies for sensors to monitor the environment. All the efforts in the NRA are directed toward development of technologies that will have applications for space research, as well as improving the state-of-the art for current Earth-based processes.

BASIS OF FY 2002 FUNDING REQUIREMENT

BIOASTRONAUTICS RESEARCH - BIOMEDICAL RESEARCH AND COUNTERMEASURES

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Biomedical Research and Countermeasures (BR&C)	57,167	70,206	66,792
Construction of Facilities	[9,000]	[8,581]	[9,800]
Minority University Research and Education Program	[1,000]	[1,000]*	

* MUREP funds were transferred to Academic Programs beginning in FY 2002.

GOALS

The goals of BR&C are to conduct research in space biomedicine that: (1) defines the strategies and develops the tools to reduce the risk to crew health from space radiation; (2) defines strategies and tools to reduce risk of acute and chronic health problems, including psychological and behavioral issues; (3) will provide tools to increase crew productivity in flight, and ensure complete crew rehabilitation for a full, healthy life on Earth; and (4) transfer biomedical knowledge and technology gained through research on the ground and in space to the Earth-based medical community.

STRATEGY FOR ACHIEVING GOALS

BR&C includes research on physiology, behavior and performance, biomedical countermeasures, operational and clinical problems, environmental health, and radiation health. BR&C seeks to characterize and determine the mechanisms of physiological change in weightlessness, including those that threaten to limit the duration of human space missions. It also develops methods that allow humans to live and work in microgravity, optimize crew safety, well-being and performance, and minimize the deleterious effects of returning to Earth's gravity after space flight. BR&C: 1) provides scientific knowledge required to specify, measure, and control spacecraft environments;

2) develops standards and countermeasures, where necessary, to optimize crew health, safety, and productivity; (3) develops monitoring techniques, procedures, and standards for extended missions; and (4) establishes the scientific basis for protecting humans engaged in the development and exploration of space from radiation hazards.

Center Support

JSC is the Lead Center for implementing BR&C work. ARC and KSC conduct Performing Center activities. JSC also manages the significant ground-based grant activities and all flight experiment activities focused on human research. ARC supports biomedical research investigations, and plays the primary life sciences role in the development of biomedical flight experiments requiring non-human subjects. KSC provides pre- and post-flight support for BR&C flight experiments. The countermeasure-focused research is managed by a cooperative agreement between NASA JSC and Baylor College of Medicine. This cooperative agreement governs the National Space Biomedical Research Institute (NSBRI), a 12-university consortium managed by Baylor College of Medicine and JSC, in developing countermeasures. The NSBRI provides a direct link to many of the Nation's top biomedical research universities.

ACCOMPLISHMENTS AND PLANS

During FY 2000, preparations continued for STS-107, OBPR's next major Space Shuttle flight opportunity, which will be dedicated to health and safety research; 13 biomedical experiments are manifested on STS-107. The experiments will focus on bacterial virulence in space, fungal growth, immune dysfunction, viral reinfection, sleep-wake activity monitoring, muscle atrophy, nutrition, balance, bone metabolism, and renal stone risk. An agreement to conduct radiation-induced genomic instability research was signed with the National Cancer Institute. Construction of the Booster Applications Facility (BAF) at Brookhaven National Laboratory (BNL) continued. In cooperation with Loma Linda University and Brookhaven National Laboratory (BNL), OBPR research used the Loma Linda Proton Beam Facility and BNL Heavy ion accelerators to simulate space radiation for radiation health research experiments. Shielding properties of one U.S. and one Russian Extravehicular Activity (EVA) suit (NASA's Extravehicular Mobility Unit [EMU] and RSA's Orlan, respectively) were measured with proton and electron beams, and the analysis of the experimental data is underway. Approximately 55 scientists from 16 U.S. institutions and one supported by the Italian Space Agency used iron and silicon beams at BNL to perform 19 experiments involving the exposure of more than 1,300 biological samples using 165 hours of beam time. Research studying the interaction of high-energy charged particles with matter showed that hydrogen-rich materials, such as polyethylene, have superior shielding properties. This research is currently being used to improve radiation protection on board the ISS. NASA continues to participate in international efforts, including research at the Heavy Ion Medical Accelerator (HIMAC) facility of the National Institute of Radiological Sciences (NIRS) in Chiba, Japan. NASA also participates in the development of consensus recommendations to the Multilateral Medical Operation Panel for radiation protection on the ISS, and international workshops jointly sponsored with the Japanese and Italian space agencies, as well as with NIRS.

An integrated Critical Path Research Plan was baselined and placed on a website on the Internet for community comment (http://criticalpath.jsc.nasa.gov). It outlines a biomedical risk-based mitigation strategy for defining research requirements and selecting research to support future successful long-duration human space flights. This plan will be used as a guide for selection of peer-reviewed research based on program relevance.

FY 2001 plans include continued logistics planning for the initial research on the ISS. The Crew Health Care System (CHeCS) and the first rack of the Human Research Facility (HRF) will be deployed to the International Space Station, and OBPR will begin initial operations of these facilities. Following the FY 2001 budget increase in Bioastronautics, a significant portion of which went to the National Space Biomedical Research Institute (NSBRI) to strengthen countermeasure development and improve the safety and performance of flight crews, the NASA Chief Scientist had a distinguished external panel review the NSBRI. The panel recommended continued funding of the NSBRI; however, they also had recommendations for improvement, which will be reviewed by NASA and the NSBRI.

BR&C continues funding for the BAF construction at Brookhaven National Laboratory from within the baseline BR&C program budget. The BAF will provide the capability to simulate all major ion components and energies of galactic cosmic rays and solar proton events. Once the BAF becomes operational, Brookhaven National Laboratory will provide NASA access to more than 600 beam-hours–per year in order to meet the goals of the NASA Strategic Radiation Health Plan.

BR&C will continue to expand research operations on the ISS. OBPR is preparing a wide range of experiments for flight on the International Space Station in FY 2001, and is developing an expanded research program to take full advantage of growing ISS capabilities in the future. Over the next three years, 11 research projects are planned for Station increments 2 through 10. Facilities for human research and the Microgravity Science Glove Box will be available to support this research as part of the continuing deployment of the ISS.

FY 2002 includes planning for a possible Shuttle research flight beyond STS-107; this R2 mission is currently under review. Crew health and safety, as well as public health and outreach will be the BR&C highlights for this mission. Six experiments are proposed, focusing on balance, microbial growth, bone metabolism, renal stone risk, growing food, and producing safe drinking water. Also, the BAF construction progresses toward completion in FY 2003, with plans for the beginning of operational research.

MUREP transferred to Code F in FY 2002 to consolidate Agency educational activities and provide renewed focus for educational priorities.

BASIS OF FY 2002 FUNDING REQUIREMENT

FUNDAMENTAL SPACE BIOLOGY

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Fundamental Space Biology (FSB) (Formerly Fundamental Biology (FB))	38,180	40,610	39,200

GOALS

The goals of FSB are to: (1) effectively use microgravity and the other characteristics of the space environment to enhance our understanding of fundamental biological processes; (2) develop the foundation of fundamental biological knowledge required to enable a long-duration human presence in space, and to provide the biological understanding to support other biologically-related NASA activities; and (3) transfer biological knowledge and technology gained through research on the ground and in space to the medical and scientific communities.

STRATEGY FOR ACHIEVING GOALS

Investments in FSB will improve understanding of the role of gravity in biological processes and provide new knowledge about biological systems on Earth. This will be accomplished by using a variety of gravitational environments as research tools and by determining the combined effects of gravity and other space environmental factors on biological systems. The emphasis is on research in cell and molecular biology, evolutionary and developmental biology, and organismal and comparative biology. This research includes plants, animals, or other organisms as subjects, as well as cell or tissue cultures. The disciplines supported are Physical Interactions, Cellular and Molecular Biology, Evolutionary Biology, Developmental Biology, Organismal and Comparative Biology, Global Monitoring and Disease Prediction, Gravitational Ecology, as well as outreach activities.

Center Support

ARC is the Lead Center for implementing FSB, with other Performing Centers used to administer tasks or for their unique expertise. KSC provides pre- and post-flight support for FSB flight experiments.

ACCOMPLISHMENTS AND PLANS

During FY 2000, FSB funded 17 new investigations, for a funding rate of approximately 13%, and released an NRA for ground-based research proposals to be funded in FY 2001. FSB flight experiments provided information on the effects of exposure to microgravity on the development of the nervous system in *Drosophila* (a type of fly) and on gene expression in cultured cells. Workshops were held in the area of developmental biology to assist in the planning of future research efforts for both flight and ground studies. Planning for the collection of normative data on targeted model organisms to assist future ISS research was begun.

During FY 2001, the transition of Fundamental Biology in the former Life Sciences Division to the Fundamental Space Biology Division will be completed. Strategic planning for the new Division will be carried out in conjunction with the Lead Center Program Office. A wider range of investigations in Fundamental Space Biology will be supported. FSB will solicit flight research as part of the International Space Life Sciences Strategic Working Group (ISLSSWG) flight solicitation and will release its annual solicitation for ground research. Collaborative efforts with the Astrobiology Program will be planned, including funding of research at the Astrobiology Institute. Increased integration and coordination of the FSB with other components within OBPR, including biomedical and biotechnology research, will be implemented.

During FY 2002, FSB will increase fundamental knowledge in the biological sciences and address critical questions in crew health and safety by conducting flight investigations on the STS-107 Space Shuttle mission and ISS. These include investigations of: the effects of gravity on plant growth and physiology, the effect of the space environment on bacterial virulence, the effect of microgravity on skeletal myofibers, avian development in space, the effects of microgravity on bone as a function of age, changes in gene expression in bacteria in space, and the effects of gravity on plant photosynthesis and respiration. The programmatic capability of FSB will be enhanced, including the study of genomics and other cellular mechanisms, through both ground-based and space flight experiments. Research Announcements for ground-based and flight research will be released.

BASIS OF FY 2002 FUNDING REQUIREMENT

PHYSICAL SCIENCES RESEARCH – MICROGRAVITY RESEARCH

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Physical Sciences Research (PSR) (Formerly Microgravity Research (MR))	108,475	130,659	130,087

GOALS

The goals of PSR are to: (1) carry out cutting-edge, and multi- and cross-disciplinary basic research enabled by the space environment to address NASA's goal of advancing and communicating knowledge; (2) develop a rigorous cross-disciplinary scientific capability, bridging the physical sciences and biology to address NASA's human and robotic space exploration goals; (3) establish the International Space Station facilities as unique on-orbit science laboratories addressing targeted scientific and technological issues of high significance; and (4) enhance the knowledge base, benefiting Earth-based technological and industrial applications.

STRATEGY FOR ACHIEVING GOALS

PSR strategy for achieving the goals includes sustaining leading-edge research focused in three areas: (1) Fundamental Microgravity Research (which includes combustion science, fluid physics, fundamental physics, materials science, and exploration research); (2) Biotechnology and Earth-based applications (which encompasses cellular biotechnology, macromolecular biotechnology, and earth-based applications); and (3) Biomolecular Physics and Chemistry. PSR will continue to effectively engage the national research community, fostering a synergistic and creative interdisciplinary community, which provides value to NASA for achieving its strategic goals. PSR's research community will promote the exchange of scientific knowledge and technological advances among academic, governmental, and industrial communities, and disseminate the results to the general public and educational institutions. PSR will enable this research through the development of an appropriate infrastructure of ground-based facilities, diagnostic capabilities, and flight facilities and opportunities. Additionally, PSR will raise the awareness in the Physical Sciences Research community (formerly microgravity research) regarding the long-term direction of the recently established OBPR, and discuss with the community the role of Physical Sciences Research in support of Agency objectives.

Center Support

MSFC is the Lead Center for PSR's Fundamental Microgravity Research, Biotechnology and Earth-Based Applications. During FY 2002, plans are to designate the Ames Research Center (ARC) as the Lead Center for PSR's area of Biomolecular Physics and Chemistry. The process of delegating management of specific science disciplines and associated hardware development to ARC, GRC, JPL, JSC, and MSFC continues. All Centers provide pre- and post-flight support for PSR flight experiments. In addition, The National Center for Microgravity Research on Fluids and Combustion, under a joint cooperative agreement among the Universities Space Research Association, Case Western Reserve University, and NASA, leads a national effort to increase both the number and quality of researchers, and to accomplish integrated, critical-path research in microgravity fluids physics and combustion science.

ACCOMPLISHMENTS AND PLANS

During FY 2000, PSR enabled broad, productive ground-based and space-based research, which included the first long-duration experiment on the ISS. The Protein Crystal Growth-Enhanced Gaseous Nitrogen Dewar (PCG-EGN) was launched on STS-106 in September 2000 and returned to Earth on STS-92, launched in October 2000. Proteins were crystallized in this dewar (a thermally controlled container) during its stay aboard the ISS for analysis in laboratories on the ground upon return. This particular payload had support from both middle and high schools in four states (Alabama, California, Florida, and Tennessee). The Principal Investigator worked with numerous middle and high school science teachers and students to train them in aspects of structural biology and protein crystallization, allowing the students to prepare protein samples that ultimately flew aboard the payload. Upon return of the samples on STS-92 to the schools, analysis was begun. Different protein samples flew on the dewar on STS-98 (February 2001) and are planned for flight on STS-102 (March 2001). This experiment went from identification of flight opportunity, through the analytical integration process, to flight in eight months. While the number of future experiments will preclude a compressed schedule for all payloads, this shortened integration process addresses a long-standing concern, demonstrating that NASA is capable of integration and flying experiments on short notice.

Three investigations using suborbital rockets were targeted for FY 2000, and two of these were completed. The third suborbital rocket investigation was deferred until mid-FY 2001 due to technical delays in preparation of both the sounding rocket and the payload. The two completed investigations were the Subcooled Pool Boiling Heat Transfer Mechanisms In Microgravity, launched in the first quarter of FY 2000, and the Extensional Rheology Experiment (ERE), launched during the fourth quarter of FY 2000. The Subcooled Pool Boiling Heat Transfer Mechanisms in Microgravity project was successfully conducted, and the final report was completed during the fourth quarter of FY 2000. While the second flight was also completed, the ERE project had significant hardware failures, resulting in the minimum science requirements not being met. However, the project is continuing to analyze the limited science data received and the engineering data received to understand the hardware performance and nature of the failures. The Spread Across Liquids (SAL-6) experiment, deferred from FY 2000, is projected for a suborbital rocket in second quarter, FY 2001. No additional sounding rocket flights are scheduled beyond this flight, as the resources used for sounding rocket research will be more effectively employed in funding microgravity research aboard the Space Station.

Using the Protein Crystallization Apparatus for Microgravity (PCAM) research results from the Microgravity Space Lab (MSL)/Microgravity Space Lab-Reflight (MSL-R) Spacelab missions continued to produce exciting results during FY 2000. Protein and enzyme crystals of exceptional quality were grown; this will help answer questions related to the nervous system and DNA processes.

The Coarsening in Solid-Liquid Mixture Investigation also continued evaluation of the MSL-1/MSL-1R flight data, which reinforced theories extending the “zero-volume fraction” theory of coarsening to the finite volume cases. These new data and theories are of great interest to manufacturers and users of high temperature materials; use of the older formulae leads to erroneous results. Convection had previously been believed to be insignificant during crystal growth of ZnSe and related ternary compound semiconductors during the use of low-vapor-pressure Physical Vapor Transport techniques. Theoretical modeling, backed up by experimental results, has proven this premise to be incorrect. The work has been published in the "Journal of Crystal Growth."

Spacecraft Fire Safety data were verified through cooperative US/Russian MIR experiments. The flammability of selected U.S.-supplied plastic materials was tested under microgravity conditions in a Russian-supplied combustion tunnel operated on the Mir space station. The data were compared to reference testing of the flammability, heat release, thermal properties, and combustion products of identical materials in ground laboratories at both the Russian Keldysh Research Center and the NASA JSC White Sands Test Facility. This cooperative research investigation was concluded during the second quarter of FY 2000 with the publication of a final report.

Exciting fundamental research results were obtained from fluid physics experiments conducted on MIR. In the experiment "Growth and Morphology of Supercritical Fluids," led by a U.S./French team of scientists, it was observed that in a fluid consisting of liquid and gas phases on the verge of a transition, the gas temperature can exceed that of its surrounding heat source, a condition known as local overheating. This counterintuitive effect was predicted theoretically a decade ago, and it demonstrates the complex nature of heat transfer in fluids. It is a significant milestone in our understanding of phenomena such as the boiling of fluids and heat transfer in gas-liquid systems.

A book on microgravity combustion research tentatively titled Fire in Free Fall was requested by, and recently submitted to, Academic Press, a subsidiary of Harcourt Brace, as an introduction to the progress made in understanding combustion in a microgravity environment. This over-400-page book was written after ten to fifteen years of research using drop towers, aircraft, and occasionally spacecraft.

Combustion synthesis, or self-propagating high temperature synthesis, has been investigated as a means of synthesizing a wide range of advanced materials, such as ceramics, intermetallics, metal matrix, and ceramic matrix composites. Recent ground-based results show that these advanced materials can be easily formed, and their porosity can be controlled in the range of what is required for bone replacement.

Activities within Cellular Biology continued during FY 2000, with the signing of the agreement for the first major private investor in space research. Fisk Ventures will use the NASA bioreactor as the basis for research and commercial development on the ground as well as in space. Other significant activities included the signing of an agreement with Wiley and Sons Publishing for a textbook on Basic and Applied Space Cell Biology, and securing a dedicated issue of the journal “In Vitro Biology” for NASA-sponsored research in a cell-based system using the Bioreactor in the near future.

For the first time, in-situ coarsening has been observed in an experiment entitled "Evolution of Local Microstructures." Studies of liquid-liquid coarsening on slides have shown for the first time the evolutionary nature of the process. Areas were observed over periods of months, and the growth kinetics of 3-D "particles" in a 2-D matrix was monitored in real-time. These results are very important in the context of strengthening mechanisms in high temperature materials.

Results from ground-based research in Colloidal Stability in Complex Fluids were highlighted on the cover of the October 2000 "Journal of the American Ceramic Society." Nano particles of ceramics interspersed within particles of silica have been shown to modify considerably the properties of the resultant fluid. This work has important applications for advanced ceramics manufacture. In the study of colloidal suspensions, it was reported that 3-D ordered colloid systems with structures comparable to the wavelength of visible light might find important applications as photonic crystals, optical switches and filters, and chemical sensors. Research development in the Fundamental Physics discipline revealed a significant cooperative achievement with the Commerce Department's National Institute of Standards and Technology (NIST). Science team members of the Primary Atomic Reference Clock in Space (PARCS) research project developed a laser-cooled fountain clock in collaboration with NIST, and placed into operation a new atomic clock that will neither gain nor lose a second in nearly 20 million years. Termed NIST-1, the new cesium atomic clock at NIST's Boulder, Colorado laboratories began its role as the Nation's primary frequency standard by contributing to an international pool of the world's atomic clocks that are used to define Coordinated Universal Time (known as UTC), the official world time.

Technology development in the area of Atomic Physics has led to a technique to amplify a beam of atoms. The process for performing and detecting the amplification involves the use of a Bose-Einstein Condensate (BEC) cloud and light pulses. In the sequence of light pulses, the third light pulse demonstrates that the atoms in the matter wave were increased, or amplified. The atom amplification process is one study to help improve the accuracy of atomic instruments that are used in ground, air, and space navigation.

Work on Advanced Concepts for Radiation Shielding continued. Two workshops with invited prominent scientists were held to study the requirements for materials for protecting crewmembers during long duration space flight. The first workshop concentrated on reviewing existing transport codes and establishing their accuracy. The ultimate objective is to provide engineering teams with comprehensive transport property values for engineering materials. The second workshop examined revolutionary concepts for radiation shielding. This included an evaluation of many varied shielding concepts, ranging from using electromagnetic and electrostatic fields to using extraterrestrial resources, such as comets, asteroids, orbital debris, to employing novel materials, including hydrides, hydrogen-stuffed carbon nanotubes, or solid or liquid hydrogen.

The mission integration functions for the Alpha Magnetic Spectrometer (AMS) experiments are provided as part of NASA's efforts in Fundamental Physics. This investigation is a collaboration of NASA and the Department of Energy (DOE) and represents an international effort led by Nobel laureate Professor S. Ting to perform accurate and long-duration measurements of energetic cosmic rays spectra in search of dark matter and antimatter, utilizing the International Space Station.

In FY 2001, the Physical Sciences Research program will continue preparation of upcoming ISS flight research (with seven potential flight opportunities), perform focused research activities on the STS-107 Research Mission, conduct the FY 2000 postponed investigation using a suborbital rocket, and conduct planning for the R2 mission. PSR plans to deliver about twenty payloads in FY 2001. The payloads will support research investigations in the areas of biotechnology (macromolecular and cell science), materials science, fluid physics, and acceleration measurement. Research proposals for the development of low-gravity technology required to advance human exploration of the solar system will be selected in mid-FY 2001. New research projects will be selected in Combustion Science and Fundamental Physics. In June 2001, a workshop on "Research Needs in Fire Safety for HEDS" will be held at the NASA Glenn Research Center, and will deal with material flammability and testing, fire detection, fire suppression, and environmental control and life support. It is expected that 50-60 leading fire researchers from around the country will participate.

In FY 2002, PSR will continue development and preparation for upcoming ISS flight research and perform focused research activities on the R2 mission. Six flights will deploy research aboard the ISS. PSR will deliver 24 payloads in FY 2002. Early ISS utilization will expand, with science investigations being conducted with the Microgravity Science Glovebox and EXPRESS Rack. An increasing number of investigations will conduct final engineering readiness reviews in preparation for experiment deployment to the ISS science research facilities. New research projects will be selected in Biotechnology, Fluid Physics, and Materials Science. The physical sciences research program has reassessed the need for the creation of National Centers for Materials Science and for Fundamental Physics. In view of the input from the scientific community (through the advisory committees), and because of the scientific realignment of OBPR, the decision has been made to forego the creation of National Centers in those specific disciplines. Instead, the plan is to acquire a research institute in Bioengineering through a competitive procurement process. This will involve the direct collaboration between academic and NASA researchers to closely integrate research at the frontiers of the bio-physical sciences.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE PRODUCT DEVELOPMENT

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Space Product Development (SPD)	14,400	13,683	14,508

GOALS

SPD: (1) facilitates the use of space for the development of commercial products and services (including appropriate supporting ground-based activities); (2) couples NASA and private sector technology development to the advantage of both; and (3) incubates commercial enterprises that use space on a profit-making basis. SPD also promotes the benefits of space-based research to industry, facilitates industry's access to space, provides space research expertise and flight hardware, and advocates the development of policies to encourage the commercial use of space.

STRATEGY FOR ACHIEVING GOALS

SPD supports the operation of the NASA Commercial Space Centers (CSC), along with the development of commercial flight research hardware for Space Shuttle, and ultimately ISS payload development. SPD provides ground-based and parabolic aircraft flight opportunities for initial commercial research efforts. As the sponsored commercial research evolves, SPD will provide support for flight hardware associated with Space Shuttle flight activity, and ultimately for payload development presently funded by the Space Station office and developed for commercial research on the International Space Station. The CSCs are partnerships of industry, universities, and local, state, and other federal agencies engaged in commercial space research. CSCs furnish an infrastructure that provides a cost-effective and efficient way for companies to conduct research in space. The CSCs initiate industry involvement in two ways: 1) by identifying and investigating industry-led research areas of commercial promise; and 2) by assessing markets for these potential research opportunities. The businesses support the research effort with cash and in-kind resources, such as technical expertise, research materials, personnel, ground facilities, and research hardware.

Center Support

SPD is managed by the Microgravity Research Program Office (MRPO) at the MSFC, and implemented primarily through the CSCs. Each CSC is a non-profit consortium of commercial and academic entities and some also have government agency participation. The CSCs follow business leads and commitments to pursue product-oriented research in three major disciplines: materials research and development, biotechnology, and agriculture. NASA's role in this partnership is to provide leadership and direction for the integrated program and to provide the flight opportunities that are essential to the success of these efforts.

ACCOMPLISHMENTS AND PLANS

In FY 2000, significant commercial research activity was conducted on Space Shuttle Mission STS-101. On this mission, two commercial research payloads were flown: Commercial Protein Crystal Growth (CPCG) and Astroculture™ Glovebox (ASC). These payloads grew large biological crystals in the microgravity environment and continued the investigation of why the absence of gravity permits an increase in the efficiency of genetically transforming plant seeds.

Substantial commercial research gains were achieved in FY 2000, including the following:

- BioServe Space Technologies reached a long-term agreement with Bristol-Myers Squibb to continue collaboration on a research project investigating ways for improving the efficiency of fermentation processes. Preliminary research conducted in prior Shuttle missions using microgravity has demonstrated up to a 200% increase in the fermentation process when compared to ground controls (STS-77). Very good results in increased antibiotic production were again attained on STS-95. BioServe and Bristol-Myers Squibb are continuing this investigation, and will fly further experiments to the ISS on STS-100, which is scheduled for spring 2001. This research could lead to methods for increasing the efficiency of antibiotic production here on Earth.

- Metal Oxide Technologies is commercializing a new technology for the use of High-Temperature Superconducting (HTS) wires using oxide thin films, developed by the Space Vacuum Epitaxy Center. This technology has been licensed, and a pilot plant for producing HTS wires for use in power line transformers is expected to be operational this year.

During FY 2000, SPD began preparations for conducting an external review of the Commercial Space Centers. This review will take place during FY 2001, and will be similar to previous reviews in that it will provide an external assessment as to how the individual CSCs are performing with respect to their mission of encouraging the commercial development of space. SPD also released the first of its annual reports highlighting CSC accomplishments. This annual report format is comparable to corporate annual reports.

Throughout FY 2001, SPD will continue its support for commercial research in biotechnology, agriculture, and materials processing. Six commercial payloads in the fields of materials research, protein crystal growth, agriculture, and fire safety will be flown on STS-107. The first four commercial research payloads, investigating antibiotic production, protein crystal growth, agricultural research, and materials research, will be flown on the International Space Station.

During FY 2002, SPD will be taking advantage of anticipated increased flight opportunities for commercial research. Sixteen payloads are manifested for the ISS, and another seven commercial payloads are scheduled to fly on the Space Shuttle. Planning will continue for additional flights as the ISS assembly progresses.

BASIS OF FY 2002 FUNDING REQUIREMENT

HEALTH RESEARCH

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Health Research (HR)	8,700	11,714	9,400
Occupational Health Research (OHR)	[1,400]	[1,066]	[1,200]
Space Medicine Research (SMR)	[7,300]	[10,648]	[8,200]

* - Commencing in FY 2000, the previously separate Occupational Health Research and Space Medicine Research functional activities were combined into one single budget structure entitled Health Research, administered through the OLMSA-based Office of Health Affairs (OHA). In FY 2001, a reorganization created the Health and Medical Office within the Office of the Administrator. This new office was created from the former OHA and given additional broad responsibility for oversight and advice on all aspects of health and medical care for the ground workforce and space crews in training and in flight, medical quality assurance, and protection of human research subjects and patients. Previous responsibilities for the conduct of research relating to astronauts during space flight, countermeasures development, the Astronaut Longitudinal Study and other space medicine areas are being negotiated for disposition and funding between the Office of Biological and Physical Research and the Office of Space Fight. Once the negotiations are completed on the organizational assignment of the former HR content, the HR budget will be realigned accordingly among the three organizations.

GOALS (OCCUPATIONAL HEALTH RESEARCH (OHR))

The goals of OHR include: (1) improve NASA's Occupational Health program effectiveness and efficiency through medical quality assurance and the development of an employee health longitudinal study as part of overall knowledge management; and (2) ensure NASA compliance with all Federal safety and health requirements.

STRATEGY FOR ACHIEVING GOALS

OHR provides for policy formulation and oversight of NASA-wide occupational and environmental health activities. This function consists of several well-defined constituent activities, including Occupational Medicine, Industrial Hygiene, Radiation Health, Physical Fitness, Employee Assistance Programs, Workers' Compensation, Nutrition and Food Safety, and Wellness and Health Education. Collectively, these constituent activities ensure the health, well-being, and productivity of the NASA work force. The Kennedy Space Center (KSC) is the Performing Center for the Agency Occupational Health Program (OHP).

ACCOMPLISHMENTS AND PLANS

During FY 2000, the OHP completed the development, and began the implementation, of a web-based supervisor training module (https://solar.msfc.nasa.gov:443/solar/delivery/public/html/newindex.htm) for the identification and reduction of work-related stress. Life Skills stress management training was made available to all Centers. The draft of a stress measurement tool for measuring the effectiveness of Employee Assistance Program (EAP) interventions was reviewed. A pilot study utilizing the National Depression Screening Project was completed. Study data were compared to the national data set with no significant anomalies, but the review led to the implementation of a new contract for the provision of after-hours EAP coverage to all NASA facilities. The OHP continued its series of professional education ViTS seminars, starting with a series on Emerging Infectious Diseases, followed by a series on Aging. The series was broadcast to the Medical Informatics and Technology Applications Consortium, Medical College of Virginia, the Institute of Biomedical Problems in Moscow, the European Institute of Telemedicine in Toulouse, France, other select academic institutions within the U.S., and to all NASA Centers. A new, comprehensive audit system tool was drafted for review and approval for deployment to 50% of the NASA locations annually. The office initiated the Solar Safe program for skin cancer screening, held a workshop with national dermatology experts, published proceedings, and developed Agency metrics on skin cancer prevention and early diagnosis. Two key NASA sites hosted reviews through the Joint Commission for the Accreditation of Hospitals-affiliated Joint Commission Resources for the assessment of accreditation readiness and NASA-specific recommendations.

During 2001 and FY 2002, the OHP will continue emphasizing quality assurance for its occupational health program through the implementation of a formalized, medical quality assurance program inclusive of credentialing and privileging. OHP will continue its support of certification efforts for safety and health programs under the Occupational Safety and Health Administration Voluntary Protection Program, and will continue its professional education series with the conclusion of the Aging series and initiation of a new series, "Occupational and Environmental Health Primer and Issues." OHP will continue to support the new Health Council, formed in conjunction with the establishment of the Administrator's Health and Medical Office. The Performing Center will host an Agency-wide Occupational Health Conference on risk assessment and management. Emphasis will continue to be placed on teaming with other Federal agencies for the delivery of services in a cost-effective manner. Wherever subject matter expertise can be obtained through interagency agreements, those agreements will be effected.

GOALS (SPACE MEDICINE RESEARCH (SMR))

The goals of SMR are to: (1) ensure the health, safety, and performance of space flight crew members, in training and in flight, for all U.S. Space Shuttle, ISS, and exploration missions; and (2) oversee the establishment of requirements for clinical care and medical research and ensure the protection of human research subjects and patients.

STRATEGY FOR ACHIEVING GOALS

Within SMR, there are five primary elements: (1) mission support for the Space Shuttle and ISS Program; (2) astronaut health care; (3) epidemiology (longitudinal studies of astronaut health); (4) Crew Health Monitoring and Risk Mitigation (CHMRM); and (5) Clinical Care Capability Development Program (CCCDP). SMR functions include responsibility for oversight and approval of policies and requirements developed to maintain and provide medical support to optimize the health, safety, and productivity of our astronauts in space. This also includes technology and application developments. SMR funding provides for guidance and oversight of the medical operational support for human space flight and astronaut health care. SMR's scope ranges from the development of astronaut health policies, standards, and requirements for medical operations and medical research, as well as oversight of the implementation of these requirements, through operational medical support for all human space flight programs.

Center Support

JSC is the Lead Center for SMR. JSC manages clinical medical and psychological support for the astronauts as well as telemedicine efforts in support of medical operations activities for the Human Space Flight (HSF) Program. The major participating academic institutions are Wright State University School of Medicine, Medical College of Virginia at the Virginia Commonwealth University, and the University of Texas Medical Branch at Galveston.

ACCOMPLISHMENTS AND PLANS

During FY 2000, SMR continued its support of the needs of the space medicine community for Space Shuttle missions including operational medical support for the ISS. CHMRM funding assisted in the development, monitoring, and interpretation of operational health-related data from space flight including: support of the implementation and interpretation of Medical Requirements (MRs) for Shuttle and ISS, and IPT support of rapid responses to clinical studies relative to space medicine issues. ISS CHeCS components were deployed early in the ISS assembly sequence to provide on-orbit medical, environmental, and countermeasure capabilities for all ISS crewmembers. CCCDP funding supported the ongoing evolution of space medicine requirements, procedures, and technologies. Plans were developed to augment ISS CHeCS with new and emerging medical and environmental technologies, many of which began development at the NSBRI. Epidemiological efforts continued to evaluate the growing body of astronaut health data to better define the medical risks associated with space flight. Special emphasis was placed on clinical medical research, radiation research, and psychological/human factors.

During the second quarter of FY 2001, SMR's tasks and concomitant funding were proposed for realignment among the Health and Medical Office, the Office of Space Flight, and the Office of Physical and Biological Research to continue supporting the needs of the operational medicine community for Shuttle and ISS missions. Those negotiations are underway, and there will be no impact to the delivery of SMR products and services during the fiscal year.

During FY 2002, SMR's changed mission, as represented within the Health and Medical Office, will be one primarily of oversight, policy review and approval, advice, special studies, permanent medical waiver authority, and assurance of professional education and competency. Funding is designated for continued support of the Wright State Residency Program and the Space Medicine Fellowship, University of Texas Medical Branch at Galveston, and medical quality assurance efforts.

BASIS OF FY 2002 FUNDING REQUIREMENT

MISSION INTEGRATION

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Mission Integration (MI)	17,414	15,206	213
(University of Missouri Life Sciences Research Facility)	[12,814]	[14,967]	

GOALS

The goals of Mission Integration (MI) are: (1) provide physical, analytical, and operations integration support for Human Space Flight missions, to achieve NASA mission objectives for the science and technology communities; and (2) ensure integrated scientific, technological, and commercial user advocacy and coordination of requirements for the next generation of space laboratories, the ISS. These activities include the integration, coordination, and policy planning and analysis for international research activities within OBPR, as well as across the Agency, for ISS research.

STRATEGY FOR ACHIEVING GOALS

In order to meet the function goals and objectives, MI performs the space-based research utilization planning for all OBPR payloads flown on the Space Shuttle payloads, and planning across the Agency for science payloads flown on ISS. In addition, through this function, MI carries out systems engineering efforts to develop and evaluate strategies and processes for satisfying current and future research mission objectives. These tasks not only address the current human-based space flight platform mission integration processes, but support the development of new processes and tools for carrying out integrated research advocacy, requirements coordination, mission planning, and operations for future space platforms. In particular, the program is investigating ways to apply the engineering and operations lessons learned in the Spacelab program and the NASA/MIR Research Program (NMRP) to the ISS program to achieve greater efficiencies.

Center Support

Headquarters remains the Lead Center for planning and directing Mission Integration. JSC is the primary Center for providing the mission implementation function for Headquarters research mission activities.

ACCOMPLISHMENTS AND PLANS

During FY 2000, MI continued to support the second DOE-sponsored Alpha Magnetic Spectrometer (AMS) mission planned for the ISS, including the Preliminary Design Review (PDR) for integration on ISS and the initial safety reviews. In addition, MI continued to support Space Shuttle “pathfinder” research missions, such as STS-107, which will provide space access to the science and commercial programs until a continuing substantive research capability is available on the ISS.

Additionally, as directed by the Congress in the FY 2000 Appropriations Act, MI funded $12.814M towards the construction of a life sciences research facility at the University of Missouri, Columbia.

In FY 2001, MI transferred management oversight in support of the DOE-sponsored AMS mission, including the Critical Design Review (CDR) and the first NASA integration hardware deliveries to the DOE/AMS payload developer, to the Physical Sciences Research Division (formerly Microgravity Research). The first SpaceHab Research Double Module (RDM) will be flown on STS-107. In the interim, science research at the middeck locker equivalent (MLE) level will be flown on ISS assembly flights on a space-available basis. Plans for an additional research mission, STS 112-(R2), are being defined.

In addition, as directed by the Congress in the FY 2001 Appropriations Act, MI funded an additional $14.967M towards the construction of a life sciences research facility at the University of Missouri, Columbia.

In FY 2002, work will begin on definitizing the potential payload complement for the R2 mission.

BASIS OF FY 2002 FUNDING REQUIREMENT

INVESTMENTS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Investments (MUREP)	[1,000]	[1,000]	[--]

The OBPR Strategic Enterprise investments in higher education institutions include Federally mandated outreach to the Nation's Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), including Hispanic-Serving Institutions and Tribal Colleges and Universities. This outreach is achieved through a comprehensive and complementary array of strategies developed in collaboration with the Office of Equal Opportunity Programs. These strategies are designed to create a broadbased, competitive aerospace research capability within Minority Institutions (MIs). This capability fosters new aerospace science and technology concepts by integrating OBPR Enterprise-related cutting-edge science and technology concepts, practices, and teaching strategies into MIs' academic, scientific, and technology infrastructures. As a result, the Agency is helping to increase the number of competitively trained U.S. students from groups currently underrepresented in NASA-related fields who, because of their research training and exposure to cutting-edge technologies, are better prepared to enter graduate programs or the workplace. Other initiatives are focused on enhancing diversity in the OBPR Strategic Enterprise's programs and activities. This includes exposing faculty and students from HBCUs and OMUs, and students from underserved schools with significant enrollments of minority students, to the Enterprise's research efforts and outcomes, educational programs, and activities. The Centers and JPL support the MUREP through the availability of their unique facilities, program management and grant administration, and commitment of their personnel to provide technical and program implementation assistance. Further detail as to how this funding is utilized is located under the MUREP portion of the budget.

BASIS OF FY 2002 FUNDING REQUIREMENT

BIOLOGICAL AND PHYSICAL RESEARCH INSTITUTIONAL SUPPORT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Institutional Support to the Biological and Physical Research Enterprise.................	[65,518]	[65,859]	69,620
Research and Program Management	[60,934]	[59,543]	63,736
Personnel and Related Costs............. ..	[48,389]	[47,924]	49,678
Travel	[1,332]	[1,265]	1,298
Research Operations Support............. .	[11,213]	[10,354]	12,760
Construction of Facilities	[4,584]	[6,316]	5,884
Full-Time Equivalent (FTE) Workyears	**[485]**	**[489]**	**484**

Note - FY 2000 and FY 2001 data in this section are for comparison purposes only. See *Mission Support* sections for more details.

PROGRAM GOALS

The two primary goals of this budget segment are to:

1. Acquire and maintain a civil service workforce that reflects the cultural diversity of the Nation, and is both sized and skilled consistently with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the Biological and Physical Research Enterprise.
2. Ensure that the facilities critical to achieving the goals of the Biological and Physical Research Enterprise are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

RESEARCH AND PROGRAM MANAGEMENT (R&PM): This program provides the salaries, other personnel and related costs, travel, and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce are covered in the Personnel budget, which comprises approximately 71% of the requested R&PM funding. Research and Operations Support, which covers administrative and other support, is approximately 27% of the request. The remaining 2% of the request is required to fund the travel necessary to manage NASA and its programs.

CONSTRUCTION OF FACILITIES (CoF): This budget line item provides funding for discrete projects required by components of NASA's basic infrastructure and institutional facilities; almost all CoF funding is used for capital repair. NASA facilities are critical for the support of research conducted by the Biological and Physical Research Enterprise. NASA has conducted a thorough review of its facilities infrastructure, and determined that, 1) the deteriorating plant condition warrants increased repair and renovation efforts in order to avoid safety hazards to personnel, facilities, and mission, and 2) some dilapidated facilities need to be replaced. Increased investment in facility revitalization is required to maintain an infrastructure that is safe and capable of supporting NASA's missions.

ROLES AND MISSIONS

The detail provided here is for the support of the Biological and Physical Research Enterprise institutions: Johnson Space Center (JSC), Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), Ames Research Center (ARC), Langley Research Center (LaRC), Glenn Research Center (GRC), Goddard Space Flight Center (GSFC), Jet Propulsion Laboratory (JPL), and NASA Headquarters.

JOHNSON SPACE CENTER (JSC)

The Biological and Physical Research Enterprise funds about 4% of JSC's institutional budget. JSC is the Lead Center for implementing Advanced Human Support Technology and Biomedical Research & Countermeasures work, as well as providing the mission implementation function for Headquarters research mission activities. JSC coordinates all Performing Center activities, manages Advanced Life Support facilities, and conducts all system-level integration and testing for these facilities. JSC also manages the significant ground-based grant activities and all flight experiment activities focused on human research. Countermeasures-focused research is managed by a cooperative agreement between JSC and Baylor College of Medicine. This agreement governs the National Space Biomedical Research Institute (NSBRI), a 12-university consortium managed by Baylor College of Medicine and JSC, in developing countermeasures. JSC manages clinical medical and psychological support for the astronauts as well as telemedicine efforts in support of medical operations activities for the Human Space Flight (HSF) Program. Finally, JSC is also a Performing Center for Fundamental Space Biology, Physical Sciences Research, Space Product Development, and Mission Integration.

KENNEDY SPACE CENTER (KSC)

The Biological and Physical Research Enterprise funds about 1% of KSC's institutional budget. Kennedy Space Center manages extramural research and conducts specific research tasks directed at using plants in advanced life support systems. KSC also provides pre- and post-flight support for Biomedical Research & Countermeasures and Fundamental Space Biology flight experiments. KSC is a Performing Center for Advanced Human Support Technology, Biomedical Research & Countermeasures, Fundamental Space Biology, and Health Research.

MARSHALL SPACE FLIGHT CENTER (MSFC)

The Biological and Physical Research Enterprise funds about 4% of MSFC's institutional budget. Marshall Space Flight Center is the Lead Center for Physical Sciences Research's Fundamental Microgravity Research, and Biotechnology and Earth-Based Applications. The Microgravity Research Program Office (MRPO) at Marshall also manages Space Product Development. Marshall is also a Performing Center for Advanced Human Support Technology, Biomedical Research & Countermeasures, Fundamental Space Biology, and Health Research.

AMES RESEARCH CENTER (ARC)

The Biological and Physical Research Enterprise funds about 5% of ARC's institutional budget. Ames Research Center is the Lead Center for implementing Fundamental Space Biology, and plans are to designate ARC as the Lead Center for Physical Sciences Research's Biomolecular Physics and Chemistry efforts in FY 2002. Ames supports biomedical research investigations, and plays the primary life sciences role in the development of biomedical flight experiments requiring non-human subjects. ARC manages extramural research and conducts specific research tasks directed at analytical models and physicochemical processes for advanced life support systems. Ames is also a Performing Center for Advanced Human Support Technology, Biomedical Research & Countermeasures, and Health Research.

LANGLEY RESEARCH CENTER (LaRC)

The Biological and Physical Research Enterprise does not fund LaRC's institutional budget, due to the limited amount of OBPR work done at the Center. Langley Research Center is a Performing Center for Physical Sciences Research.

GLENN RESEARCH CENTER (GRC)

The Biological and Physical Research Enterprise funds about 5% of GRC's institutional budget. Glenn Research Center is a Performing Center for Physical Sciences Research.

GODDARD SPACE FLIGHT CENTER (GSFC)

The Biological and Physical Research Enterprise does not fund GSFC's institutional budget; the grant-related work for GSFC is done at NASA Headquarters. Goddard Space Flight Center is a Performing Center for Advanced Human Support Technology, Physical Sciences Research, Space Product Development, and Health Research.

JET PROPULSION LABORATORY (JPL)

The Biological and Physical Research Enterprise funds about 8% of JPL's institutional budget. The Jet Propulsion Laboratory is the lead for Advanced Environmental Monitoring and Control activities, bringing its personnel and industry contacts to the development of sensors and monitoring and control capability. JPL is a Performing Center for Advanced Human Support Technology, Biomedical Research & Countermeasures, Physical Sciences Research, Health Research, and Mission Integration.

NASA HEADQUARTERS

The Biological and Physical Research Enterprise funds about 9% of NASA Headquarters' institutional budget. NASA Headquarters is the Lead Center for planning and directing Mission Integration. The Enterprise's Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTEs across the Agency. A more complete description can be found in the Mission Support/Two-Appropriation Budget section.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF EARTH SCIENCE

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Major Development	921,779	836,914	709,097	
Earth Observing System	479,799	414,286	371,894	SAT 3-11
Earth Observing System Data Information System.............	278,880	281,391	252,650	SAT 3-26
Earth Explorers	163,100	141,237	84,553	SAT 3-31
Research and Technology	466,314	579,658	516,653	SAT 3-36
Earth Science Program Science	286,399	350,626	357,453	SAT 3-37
Applications, Education and Outreach..............................	84,400	114,081	63,200	SAT 3-59
Technology Infusion	94,515	114,951	96,000	SAT 3-72
Construction of Facilities..	1,000	--	--	SAT 3-78
Mission Operations	48,007	57,778	52,250	SAT 3-79
Investments	7,300	10,277	--	SAT 3-83
Minority University Research & Education Program	7,300	8,780	--	
Education	--	1,497	--	
Institutional Support	[246,979]	[231,569]	236,978	SAT 3-85
Total..	1,443,400	1,484,627	1,514,978	

Distribution of Program Amount by Installation	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET
Johnson Space Center	36,218	33,066	18,552
Kennedy Space Center	60,985	80,798	68,708
Marshall Space Flight Center	17,642	18,478	27,567
Stennis Space Center	49,127	67,290	43,159
Ames Research Center	26,342	19,004	30,273
Dryden Flight Research Center	21,883	20,142	25,317
Langley Research Center	93,179	118,283	143,912
Goddard Space Flight Center	871,371	879,136	895,357
Jet Propulsion Laboratory	230,961	204,394	180,667
Glenn Research Center	1,917	2,707	1,375
Headquarters	33,775	41,329	80,091
Total	1,443,400	1,484,627	1,514,978

PROGRAM GOALS

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. NASA brings to this endeavor the vantagepoint of space, allowing global views of Earth system change. NASA is a provider of objective scientific information, via observation, research, modeling, and applications demonstration, for use by decision-makers in both the public and private sectors. NASA has been studying the Earth from space from its beginnings as an agency. These efforts have led to our current activity of deploying the first series of Earth Observing System satellites that will concurrently observe the major interactions of the land, oceans, atmosphere, ice, and life that comprise the Earth system. In short, the purpose of the Enterprise is to provide scientific answers to the fundamental question:

How is the Earth changing, and what are the consequences for life on Earth?

A fundamental discovery made during the 20th century, enabled in large part by NASA's global view from space, is the existence of a multiplicity of linkages between diverse natural phenomena and interactions between the individual components of the Earth system. As a result, NASA has worked with other agencies to develop a new, interdisciplinary field of "Earth system science", with the aim of investigating the complex behavior of the total Earth environment in which the global atmosphere, the oceans, the solid Earth and ice-covered regions of the Earth, and the biosphere all function as a single interactive system. Earth system science is an area of research with immense benefits to the nation, yielding new knowledge and tools for weather forecasting, agriculture, water resource management, urban and land use planning, and other areas of economic and environmental importance. In concert with other agencies and the global research community, ESE is providing the scientific foundation needed for the complex policy choices that lie ahead on the road to sustainable development.

ESE has established three broad goals through which to carry out its mission. 1) Science: Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth; 2) Applications**:** Expand and accelerate the realization of economic and societal benefits from Earth science, information and technology; 3) Technology**:** Develop and adopt advanced technologies to enable mission success and serve national priorities. These goals are articulated in the Earth Science Enterprise Strategic Plan.

NASA and its partners have already made considerable progress in understanding the Earth system. With satellites launched over the past decade, ESE has charted global ocean circulation including the waxing and waning of El Niño, mapped land cover change over the entire globe, illuminated the 3-D structure of hurricanes, and explored the chemistry of the upper atmosphere and the causes of ozone depletion. With deployment of the Earth Observing System now underway, ESE is opening a new era in Earth observation from space in which the major interactions of the Earth system are studied simultaneously to provide a global view on climate change. With this knowledge, NASA and its partners will develop prediction capabilities to quantify the effects of natural and human-induced changes on the global environment. Operational agencies such as National Oceanic and Atmospheric Administration (NOAA) and United States Geological Survey (USGS), who are partners in this effort, can use these capabilities to improve weather and climate forecasting, natural resource management, and other services on which the Nation relies.

STRATEGY FOR ACHIEVING GOALS

Science

We know that natural and human-induced changes are acting on the Earth system. Natural forces include variation in the Sun's energy output, and volcanic eruptions, which spew dust into the atmosphere and scatter incoming sunlight. Human forces include deforestation, carbon emission from burning of fossil fuels, methane and soil dust production from agriculture, and ozone depletion by various industrial chemicals. Internal climate factors such as atmospheric water vapor and clouds also introduce feedbacks that serve to either dampen or enhance the strength of climate forcing. We also know the climate system exhibits considerable variability in time and space, i.e., both short and long term changes and regionally-specific impacts.

NASA has used the concept of Earth System Science in developing its program. Researchers have constructed computer models to simulate the Earth system, and to explore the possible outcomes of potential changes they introduce in the models. This way of looking at the Earth as a system is a powerful means of understanding changes we see around us. That has two implications for Earth Science. First, we need to ***characterize*** (that is, identify and measure) the forces acting on the Earth system and its responses. Second, we have to peer inside the system to ***understand*** the source of internal variability: the complex interplay among components that comprise the system. By combining observations, research and modeling, we create a capability to ***predict*** Earth system change to help our partners produce better forecasts of change.

Earth system changes are global phenomena. Yet the system comprises many micro-scale processes, and the most significant manifestations are regional. Thus, studying such changes requires a global view at regionally discerning resolutions. This is where

NASA comes in, bringing the unique capability to study planet Earth from the vantagepoint of space. To *characterize* the forces acting on the Earth system and its responses, *understand* the source of internal variability and *predict* Earth system change, NASA must observe the Earth, conduct research and analysis of the data, model the data and synthesize the information into new knowledge. Where we are on this knowledge "life cycle" determines the strategy for our investment decisions.

The ESE is pursuing a targeted research program, focused on a set of specific science questions that can be addressed effectively with NASA's capabilities. ESE formulates comprehensive research strategies that can lead to definitive scientific answers and potentially to effective applications by other entities.

The key Earth Science research topics sponsored by NASA follow from this view of the Earth as a system. Thus they are grouped into categories of variability in the Earth System, forces acting on the Earth system, responses of the system to change, consequences of change, and prediction of future changes. Complicating this seemingly linear construct is a set of feedbacks; responses to change often become forces of additional change themselves. This conceptual approach applies in essence to all research areas of NASA's Earth Science program, although it is particularly relevant to the problem of climate change, a major Earth Science-related challenge facing our nation and the rest of the world. The ESE has articulated an overarching question and a set of strategic science questions reflecting this Earth system approach, which its observational programs, research and analysis, modeling, and advanced technology activities are directed at answering.

How is the Earth system changing, and what are the consequences for life on Earth?

- *How is the global Earth system changing?*
- *What are the primary causes of change in the Earth system?*
- *How does the Earth system respond to natural and human-induced changes?*
- *What are the consequences of changes in the Earth system for human civilization?*
- *How can we predict future changes in the Earth system?*

ESE's Research Strategy for 2000-2010 describes NASA's approach to answering these questions. The intellectual capital behind Earth science missions, and the key to generating new knowledge from them, is vested in an active program of research and analysis. Over 1,500 scientific research tasks from nearly every state within the U. S. are funded by the Earth science research and analysis program. Scientists from seventeen other nations, funded by their own countries and collaborating with U. S. researchers, are also part of the Earth science program. These researchers develop Earth system models from Earth science data, conduct laboratory and field experiments, run aircraft campaigns, develop new instruments, and thus expand the frontier of our understanding of our planet. ESE-funded scientists are recognized as world leaders in their fields, as exemplified by the award of the 1995 Nobel Prize in chemistry to two scientists who first recognized that cholorflorocarbons provided a threat to upper atmospheric ozone. The research and analysis program is also the basis for generation of application pilot programs that enable universities, commercial firms, and state and local governments to turn scientific understanding into economically valuable products and services.

Applications

NASA expects that expanded scientific knowledge of Earth processes and the utilization of advanced space-based and airborne observing techniques or facilities developed by NASA will ultimately result in practical applications beneficial to all citizens. Examples of these applications may include: quantitative weather and hydrologic forecasts over an extended range of one to two weeks; prediction of seasonal or longer-range climate variations; the prediction of impacts of environmental changes on fisheries, agriculture, and water resources; global air quality forecasts, and natural hazards risk assessments. NASA ESE has a role in demonstrating the potential applications.

ESE continues to build a viable applications, education and outreach program that bridges our focused Research and Analysis (R&A) and mission science investments towards demonstration of new remote sensing data products for industry and regional and local decision makers. The emphasis is to focus on the dissemination of information to non-traditional Earth science customers, such as States, counties and regional managers and decision-makers. A base program is funded to put the essential tools in place and pilot several key demonstration projects. Eventually we hope that our demonstration of this concept will allow products to reach a much broader user base – practically every state in the Union.

A series of regional workshops have been held around the Nation to enable a wide variety of State and local government users to explain the challenges they face that might be addressed with tools based on satellite remote sensing. One result is the establishment of regular, open, competitively selected opportunities for these organizations to propose partnerships with NASA, academia and industry to demonstrate new applications of Earth science to specific problems. Successful demonstrations are expected to lead to new commercial / state & local government transactions, while ESE moves on to the next new demonstration activity.

Technology

In addition to ensuring a robust science program, this budget contains a vigorous Advanced Technology program that supports development of key technologies to enable our future science missions. In addition to our baseline technology program that includes the New Millennium Program (NMP), Instrument Incubator and High Performance Computing and Communications (HPCC), an Advanced Technology Initiative will identify and invest in critical instrument, spacecraft and information system technologies.

The ESE will lead the way in the development of highly capable, remote and *in situ* instruments and the information system technologies needed to support coupled Earth system models. Together they will enable affordable investigation and broad understanding of the global Earth system. The ESE will emphasize the development of information system architectures to increase the number of users of Enterprise information from hundreds to tens of thousands, with the goal of providing easy access to global information for science, education and applications. Finally, ESE will work in partnership with industry and operational organizations to develop the capabilities and infrastructure to facilitate the transition of sustained measurements and information dissemination to commercial enterprises.

ESE's technology strategy seeks to leverage the entire range of technology development programs offering benefits in cost, performance and timeliness of future Earth science process and monitoring campaigns. ESE's strategy is to establish strong links to other government programs in order to maximize mutual benefit to use open competitions for ESE-sponsored technology programs to attract the best ideas and capabilities from the broad technology community, including industry and academia.

Technology investments will be made in the following areas:

- Advanced instrument and measurement technologies for new and/or lower cost scientific investigations;
- Cutting-edge technologies, processes, techniques and engineering capabilities that reduce development, operations costs, and mission risk and that support rapid implementation of productive, economical, and timely missions;
- Advanced end-to-end mission information system technologies: technologies affecting the data flow from origination at the instrument detector through data archiving, for collecting and disseminating information about the Earth system, and enabling the productive use of Enterprise science and technology in the public and private sectors.

MISSION IMPLEMENTATION

The pursuit of Earth system science would be impractical without the continuous, global observations provided by satellite-borne instruments. NASA's Earth science research program comprises an integrated slate of spacecraft and *in situ* measurement capabilities; data and information management systems to acquire, process, archive and distribute global data sets; and research and analysis projects to convert data into new knowledge of the Earth system. Numerous users in academia, industry, Federal, State, and local government use this knowledge to produce products and services essential to achieving sustainable development. Enabling us to get at the answers to the science questions, our top priority continues to be our existing near term commitments with the launch of our first series of EOS and selected Earth Explorer missions that are nearing completion. In addition, we are committed to deliver a functioning data and information system to support the processing, archival and distribution of data products for these missions. These satellites will propel the ESE into a new era of data collection, research and analysis for which both the national and international Earth science community has been preparing over the last decade.

Realizing Scientific Return from Past Investments

Preceding the EOS were a number of individual satellite and Shuttle-based missions that are helping to reveal basic processes. The Upper Atmosphere Research Satellite (UARS), launched in 1991, collects data on atmospheric chemistry. The Total Ozone Mapping Spectrometer (TOMS) instruments, launched in 1978, 1991, and 1996, measure ozone distribution and depletion. Two TOMS instruments were launched in 1996, one on the Japanese Advanced Earth Observing System (ADEOS) mission and the other on a dedicated U. S. Earth Probe. France and the U. S. collaborated on the Ocean Topography Experiment (TOPEX/Poseidon), launched in 1992, to study ocean topography and circulation. In 1997, the Tropical Rainfall Measuring Mission (TRMM) was launched to provide the first-ever measurements of tropical precipitation. Also in 1997, ESE began purchasing ocean color data from a commercial vendor based on our joint investment in the Sea-viewing Wide Field Scanner (SeaWiFS) instrument.

Opening a New Era in Earth System Science with the Earth Observing System

The Earth Observing System (EOS), the centerpiece of Earth science, is a program of multiple spacecraft (the Terra, Aqua, Aura, Landsat-7, Jason-1, ICEsat, ACRIMSAT, Seawinds, SORCE, SAGE III, QuikSCAT, and follow-on missions) and interdisciplinary science investigations to provide a data set of key parameters needed to understand global climate change

Terra was recently launched on December 18, 1999. Terra is providing key measurements that are significantly contributing to our understanding of the total Earth system. The instrument complement is obtaining information about the physical and radiative properties of clouds, air-land and air-sea exchanges of energy, carbon, and water, measurements of trace gases, and volcanology.

Landsat-7 was also launched in 1999. Landsat-7's single instrument, the Enhanced Thematic Mapper Plus (ETM+), is making high spatial resolution measurements of land surface and surrounding coastal regions. This mission is successfully providing data continuity with previous Landsat measurements. Landsat data are used for global change research, regional environmental change studies, and other civil and commercial purposes.

The QuikSCAT spacecraft was launched in June 1999. QuikSCAT, carrying instruments to collect sea surface wind data, is filling the gap in such critical data between ADEOS 1, which failed in June 1997 after seven months on-orbit, and ADEOS II. The availability of components of the Seawinds instrument originally planned for launch on Japan's ADEOS II was accelerated to fly on QuikSCAT. Japan has yet to decide on the timing and form of an ADEOS II mission (or missions), but the ESE still intends to fly a Seawinds instrument in that context as the follow-on instrument to QuikSCAT. It now appears that ADEOS-II will be launched no earlier than 2002 with the delay due to a failure of the Japanese H-IIA launch vehicle.

The Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat) was launched on December 20, 1999 providing for the continuation of the long-term, quantitative understanding of the solar forcing of Earth's climate.

The Earth Explorers Program contains a series of focused, rapid development missions to study emerging science questions and processes utilizing innovative measurement techniques as a complement to the systematic measurements made through the EOS. The Shuttle Radar Topography Mission (SRTM) flown on STS-99 in February 2000 was a joint NASA and National Imaging and Mapping Agency (NIMA) mission to create a near-global high-resolution digital elevation topographic map of the world. The data from the SRTM will allow scientists in Federal, state and local agencies and academia to study the terrain for basic research in the areas of ecology, geology, geodynamics, hydrology and atmosphere modeling.

Some missions in this category are Earth System Science Pathfinder (ESSP). Four ESSP missions have been selected, Gravity Recovery and Climate Experiment (GRACE) with launch in 2001, Vegetation Canopy Lidar (VCL) with launch TBD (launch date under review), CloudSat with launch in 2003, and the Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations – *Climatologie Etendue des Nuages et des Aerosols* (PICASSO-CENA) with launch TBD (launch date is under review). The Earth Explorers Program also encompasses various missions, which are developed in response to requirements that provide or continue highly focused Earth science process measurements. This currently is QuikTOMS (TOMS FM-5) with launch planned for June 2001. Because the launch date for Triana remains uncertain until the Shuttle manifest becomes definitized, Triana will be placed in storage following completion of spacecraft development. In addition, the University Earth System Science (UnESS) program is being cancelled to fund immediate priorities in the Earth Science budget. A small amount of funding will be retained for these activities to complete contractual obligations associated with proposal evaluations.

EOS and related missions in development and preparation for launch through 2003 are:

- QuikTOMS (2001) - Atmospheric ozone and aerosols
- SAGE III (2001) - Stratospheric aerosols and gases experiment
- Jason (2001) - ocean topography; successor to TOPEX/Poseidon
- Aqua (2001) - atmospheric temperature and humidity, clouds, sea surface temperature, biosphere
- GRACE (2001) – time variations of Earth's gravity field
- ICEsat (2001/02) - ice sheet topography
- SORCE (2002) – solar irradiance
- SeaWinds (2002) – on Japan's ADEOS II satellite; ocean winds successor to QuikSCAT
- Vegetation Canopy Lidar (TBD) - Forest canopy height
- Aura (2003) - Upper and lower atmospheric chemistry
- Cloudsat (2003) - 3-d cloud profiles
- PICASSO-CENA (TBD) – 3-d aerosol profiles

The EOS Data and Information System (EOSDIS) is operating the EOS satellites now in orbit, and retrieving flight data and converting it into useful scientific information. EOSDIS is nearly complete; remaining segments are timed for release to support the upcoming launches of EOS missions through Aura in 2003. Following the recommendation of the National Research Council, NASA is exploring the creation of a federation of Earth science information partners in academia, industry and government to broaden the participation in the creation and distribution of EOSDIS information products. As a federation pilot project, 24 organizations were competitively selected in December 1997 to become Earth Science Information Partners (ESIPs) to develop innovative science and applications products. This is part of a broader analysis of how ESE's approach to data and information systems services should evolve in the future. In addition to the EOSDIS that will produce data products for a wide range of users, NASA is engaging in a variety of activities to extend the utility of Earth Science data to a broader range of users such as regional Earth science applications centers, Earth science information partners, and efforts are under way to fuse science data, socio-economic data and other data sets that can be "geo-referenced" in readily understandable data visualizations.

The measurements to be made by these and other future Earth science missions as well as current on-orbit missions provide data products that are used extensively in the Earth science program. These activities are providing an ever increasing scientific understanding of global environment and the effects of natural and human sources of change.

Preparing for the Next Decade of Scientific Discovery

In parallel with deploying EOS, NASA ESE is looking ahead to determine what will be the important Earth science questions in the next decade, and which require NASA's leadership to be answered. Drawing on existing reports of the National Academy of Sciences and the state of progress in current scientific endeavors, ESE has developed a *Research Strategy for 2000-2010* that articulates a hierarchy of one overarching question, five broad subordinate questions and twenty-three detailed questions that can and should be tackled over this decade. For each, the Research Strategy defines the observational requirements, which in turn provide the basis for definition of candidate missions to be pursued. An early, high priority in this timeframe is the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Program (NPP), which will serve to provide continuity with the Terra and Aqua missions as well as a demonstration of instruments for the converged weather satellite program. NASA and the Integrated Program Office (IPO) jointly fund the NPP mission. The IPO consists of representative from the three agencies participating in NPOESS – NASA, the National Oceanic and Atmospheric Administration, and the Air Force. Another priority is the Landsat Data Continuity Mission to succeed Landsat 7. As with Landsat 7, this mission is being planned in partnership with the U.S. Geological Survey (USGS). NASA and USGS are also working with industry to explore the potential for a commercial purchase of Landsat-type data to meet this data continuity requirement.

In NASA's FY 2001 appropriation, Congress included funds for concept definition work for potential missions to observe global precipitation, global earthquakes, and global tropospheric winds. Studies are underway, with further definition work anticipated to proceed in FY 2002. Also in FY 2002, ESE plans to begin similar definition activities for observation of global ocean topography and ocean surface winds to succeed Jason and SeaWinds on ADEOS II, respectively. Beginning in FY 2001, NASA is soliciting its third round of ESSP missions, with selection(s) anticipated in FY 2002.

In developing its measurement/mission strategy, the ESE desires to reduce the risk to overall program objectives from any single mission failure by developing smaller, less expensive missions and implementing shorter development cycles from mission definition to launch. Shorter development times will allow more flexible responses to current and evolving scientific priorities and more effective uses of the latest technologies. In accordance with this philosophy, the implementation of each successive future mission in the ESE flight program will be based on specific solicitation alternatives (e.g. Announcement of Opportunity, Request for Proposal, etc.) and competitive selection of instrument payloads and implementation options. In each solicitation, we will ask commercial industry to come forward and offer science-quality data that meet NASA requirements for NASA to purchase. It is important, under this new approach, that instrument technology developments be conducted largely before the relevant mission payload selection. A science and applications-based space-based measurement concept set is indispensable to guide these pre-mission technology developments, particularly the Enterprise's Instrument Incubator Program. Our goal is to reach a mission development cycle of two-three years from the time of selection.

Finally, along with space-based observations, ESE will pursue a guided evolution of data and information system services to support missions and research in the next decade. NASA's FY 2001 appropriation also included funds to develop the "NewDISS" concept for this evolution. Studies in this arena are underway as well.

PARTNERSHIPS ARE ESSENTIAL TO SUCCESS IN EARTH SCIENCE

The challenges of Earth System Science, sustainable development, and mitigation of risks to people, property and the environment from natural disasters, require collaborative efforts among a broad range of national and international partners. NASA's Earth science research program constitutes its contribution to the U.S Global Change Research Program (USGCRP), an interagency effort to understand the processes and patterns of global change. The USGCRP coordinates research among ten U. S. government agencies. NASA is by far the largest partner in the USGCRP, providing the bulk of USGCRP's space-based observational needs.

NASA has extensive collaboration with the NOAA on climate-related issues. The ESE is the responsible managing agent in NASA for the development of NOAA's operational environmental satellites. NOAA, NASA, and the Department of Defense (DoD) jointly work to achieve the convergence of civilian and military weather satellite systems. NASA collaborates with the USGS on a range of land surface, solid Earth and hydrology research projects. NASA and USGS collaborate in the Landsat-7 program, and NASA, DoD and USGS are working together on a third flight of the Shuttle Radar Laboratory modified to yield a digital terrain map of most of the Earth's surface. NASA participates in the World Climate Research Program, the International Geosphere/Biosphere Program, and the ozone assessments of the World Meteorological Organization.

International cooperation is an essential element in the Earth science program. Earth science addresses global issues and requires international involvement in its implementation and application. Acquiring and analyzing the information necessary to address the science questions is a bigger task than a single nation can undertake. Furthermore, the acceptance and use of the scientific knowledge in policy and resource management decisions around the world require the engagement of the international scientific community. Global data and global participation are needed to devise a global response to environmental change. In addition, integrating our complementary science programs can result in fiscal benefits to the NASA program. For this reason, NASA has sought and nurtured international partnerships spanning science, data and information systems, and flight missions. Most of Earth science's satellite missions have international participation, ranging from simple data sharing agreements to joint missions involving provision of instruments, spacecraft, and launch services. In the past three years over 60 international agreements have been concluded and more than 40 more are pending. In some capacity, Earth science programs involve international partners from over 35 nations, including Argentina, Armenia, Australia, Belgium, Brazil, Canada, Chile, China, Denmark, Egypt, France, Germany, India, Israel, Italy, Japan, Mongolia, Russia, South Africa, Ukraine and others.

BASIS OF FY 2002 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Terra	12,400	3,325	2,370
Aqua (formerly PM-1)	85,900	53,506	14,500
Aura (formerly Chemistry)	112,800	99,467	80,600
Special Spacecraft	121,049	111,195	56,350
QuikSCAT	1,100	1,091	3,303
Landsat-7	9,850	1,397	1,700
Algorithm Development	121,700	89,303	83,449
EOS Follow-on	15,000	55,002	129,622
Total	479,799	414,286	371,894

PROGRAM GOALS

The overall goal of the Earth Observing System (EOS) is to advance the understanding of the entire Earth system on a global scale by improving our knowledge of the components of the system, the interactions between them, and how the Earth system is changing. The EOS data will be used to study the atmosphere, oceans, cryosphere, biosphere, land surface and solid Earth, particularly as their interrelationships are manifested in the flow of energy and in the cycling of water and other chemicals through the Earth system.

The EOS program mission goals are to:

(1) Create an integrated, scientific observing system emphasizing climate change that will enable multi-disciplinary study of the Earth's critical, life-enabling, interrelated processes.
(2) Develop a comprehensive data information system, including data retrieval and processing system.
(3) Serve the needs of scientists performing an integrated multi-disciplinary study of planet Earth and to make Earth science data and information publicly available.
(4) Acquire and assemble a global database for remote sensing measurements from space over a decade or more to enable definitive and conclusive studies of Earth system attributes.

STRATEGY FOR ACHIEVING GOALS

The EOS contributes directly to accomplishing the goal of understanding global climate by providing a combination of observations made by scientific instruments, which will fly aboard the EOS spacecraft. The data are received, archived, processed, and distributed by the EOSDIS.

The three main EOS spacecraft that will support observations by the scientific instruments include the Terra, Aqua, and Aura missions. The Landsat-7 mission, successfully launched on April 15, 1999, provides additional observations.

Nearly all-key EOS missions include international contributions. For example, the Terra spacecraft is flying an instrument from Canada the Measurements of Pollution in the Troposphere (MOPITT) and one from Japan, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER); Aqua will include the Japanese Advanced Microwave Scanning Radiometer (AMSR) for EOS instrument and the Humidity Sounder for Brazil (HSB). Aura will include the Dutch-Finnish Ozone Monitoring Instrument (OMI) as well as the High-Resolution Dynamics Limb Sounder (HRDLS) instrument jointly produced by the U.S. and the United Kingdom. In addition, numerous agreements have been signed for joint data exchange and distribution, including cooperation with the EOSDIS.

The 1997 Biennial Review documented the shift in paradigm for future mission planning vis-a-vis the EOS era. Where EOS mission planning proceeded from science to mission selection to technology development, future mission planning proceeds from science to technology development to mission selection. This has the effect of removing technology development from the critical path of mission implementation, where it introduces added cost and schedule risk. Instead, technologies are matured in the context of a science-driven advanced technology program, and only when they reach a specified level of maturity are they available for use in mission proposals. The result is a more flexible and less expensive approach to acquiring Earth science data.

Terra

A new generation of Earth science began with the launch and checkout on December 18, 1999 of Terra - one that studies the Earth as a global system. Terra's five complementary instruments are designed to obtain information about the physical and radiative properties of clouds and aerosol; the exchanges of energy, carbon and water between the air, land and water; measurements of important trace gases in the atmosphere and volcanology. Terra has a descending equatorial crossing time of about 10:30 AM, typically with minimum cloud cover over land, so surface features can be more readily observed. Terra's orbit places it only 30 to 40 minutes behind Landsat-7 providing good synergy between these spacecraft. Terra's Clouds and Earth's Radiant Energy System (CERES) instrument is performing measurements of the Earth's "radiation budget" or the process by which the Earth's climate system maintains a balance between the energy that reaches the Earth from the Sun, and the energy that radiates from Earth back into space. The components of the Earth system that are important to the radiation budget are the planet's surface, atmosphere, and clouds. Meanwhile, the Moderate-Resolution Imaging Spectroradiometer (MODIS) is measuring clouds, moisture and temperature profiles of the atmosphere, land and ocean temperature, snow cover, and information about the state of the land and ocean portions of the biosphere. CERES and MODIS will also fly on the Aqua spacecraft discussed below. The Multi-angle Imaging Spectroradiometer (MISR) instrument is measuring the variation of the surface, aerosol, and cloud properties with nine different views designed to provide more detailed information about their distribution and structure. The Canadian Measurements of

Pollution in the Troposphere (MOPITT) instrument is an infrared gas-correlation radiometer that is providing global measurements of carbon monoxide and methane concentration and distribution in the troposphere. The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument, provided by Japan, is the "zoom lens" of Terra, providing the highest resolution measurements from that platform of cloud properties, vegetation, surface mineralogy, soil properties, and surface temperature. ASTER's two visible -near infrared cameras also enable it to produce high quality digital elevation models. The primary contractors associated with the project are Lockheed Martin Missiles and Space (LMMS) for the Terra spacecraft, Raytheon/Santa Barbara Remote Sensing for the MODIS instrument, TRW for the CERES instrument (the instrument has also been flown on the TRMM in 1997), JPL for the MISR instrument, Japan's MITI for ASTER, the Canadian Space Agency for MOPITT, and Lockheed Martin Commercial Launch Services for the Terra Atlas Centaur/IIAS launch services.

Aqua

The Aqua mission is focused on a large variety of measurements related to the Earth/atmosphere system, including atmospheric temperature and humidity profiles, clouds, precipitation, snow cover over the land, sea ice cover over the oceans, sea-surface and land-surface temperatures, land and ocean productivity, soil moisture, and the Earth's radiation budget. The atmospheric temperature and humidity profiles in particular are expected to lead to improvements in weather prediction. The goals of the mission include improved understandings of cloud formation, precipitation, and evapotranspiration. An afternoon equatorial crossing is more suitable for acquiring the data than a morning crossing because in most regions of the Earth there is more cloud coverage in the afternoon than in the morning; hence the 1:30 p.m. equatorial crossing time of the Aqua mission. The primary contractors associated with the project are TRW for the EOS common spacecraft to be used for Aqua and also for Aura; Lockheed Martin Infrared and Imaging Systems (LMIRIS) and JPL for the Advanced Infrared Sounder (AIRS); Aerojet for the Advanced Microwave Sounding Unit-A (AMSU-A); TRW for the Clouds and the Earth's Radiant Energy System (CERES) instrument; and Raytheon/Santa Barbara Remote Sensing for the Moderate Resolution Imaging Spectroradiometer (MODIS). Japan has provided the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), and Brazil has provided a microwave instrument, the Humidity Sounder for Brazil (HSB). All instruments were delivered to TRW by the end of 1999. This mission will be launched no earlier than July 2001. Boeing provides the launch vehicle and services for the EOS Aqua mission.

Aura

The Aura mission will study the chemistry and dynamics of the Earth’s atmosphere with emphasis on the upper troposphere and lower stratosphere (5-20 km). The mission will measure ozone, aerosols, and several key atmospheric constituents that play an important role in atmospheric chemistry, air quality, and climate. Four instruments will fly on Aura: The High Resolution Dynamic Limb Sounder (HIRDLS), being built jointly by NASA and the United Kingdom, is an infrared limb-scanning radiometer designed to sound the upper troposphere, stratosphere and mesosphere; the Microwave Limb Sounder (MLS) will measure the stratospheric temperature and numerous chemical species; the Tropospheric Emission Spectrometer (TES) is a high resolution infrared imaging Fourier transform spectrometer that observes in the limb and nadir; and the Ozone Monitoring Instrument (OMI), being built by the Netherlands Space Agency and the Finnish Meteorological Institute, is an ultraviolet and visible grating spectrometer providing global mapping of the ozone, trace gasses, and aerosols. During FY 2000, the spacecraft successfully completed a delta Preliminary Design Review and a delta Critical Design Review, and began bus integration; and the OMI successfully completed a delta CDR. In FY 2001 the spacecraft bus will complete assembly and test and begin integration. In FY 2002, all of the instruments will be delivered and integrated onto the spacecraft and observatory level testing will begin. The launch of Aura is scheduled for July 2003. Boeing provides the launch vehicle for the EOS Aura mission.

Special Spacecraft

The Special spacecraft are designed to study atmospheric aerosols, ocean circulation, and ice-sheet mass balance, cloud physics, atmospheric radiation properties, and solar irradiance. Although there have been delays with the Russian launch vehicle and spacecraft, the joint US/Russian Meteor/SAGE-III mission is presently scheduled for a late May/early June 2001 launch. A second SAGE-III instrument is scheduled to fly aboard the International Space Station in 2005. Planning activities have been initiated for a joint mission with Argentina for flying the third SAGE-III instrument. The SAGE-III takes advantage of both solar and lunar occultation to measure vertical profiles of aerosols, ozone, and other gaseous constituents of the atmosphere and will continue a more than 25 year record of well-calibrated ozone profile data.

The Japanese will provide the Advanced Earth Observing System II (ADEOS II) spacecraft for the Seawinds instrument to measure ocean surface wind velocity as a follow-on to the NASA Scatterometer instrument on ADEOS-I and the Seawinds instrument on QuikSCAT.

The Radar Altimetry mission, Jason, will be a follow-on to the TOPEX/Poseidon as a cooperative joint mission with the French Space Agency (CNES), with data provided to NOAA for operational purposes.

The primary objective of the Ice Cloud and Elevation Satellite (ICESat) mission is to measure ice sheet height and volume change for long-term climate variability studies. The primary contractor associated with the mission is Ball Aerospace for the spacecraft; the GLAS instrument is being built in-house at GSFC. ICESat is co-manifested with the Space Science/CATSAT mission on a Delta II launch vehicle.

The EOS ACRIMSAT will continue the measurement of Total Solar Irradiance (TSI) begun by the ACRIM instruments on the Solar Maximum Mission and UARS.

The Total Solar Irradiance Mission (TSIM) was merged with the Solar Stellar Irradiance Comparison Experiment (SOLSTICE) Mission to form the Solar Radiation and Climate Experiment (SORCE) Mission. SORCE will accomplish all the original science objectives of both TSIM and SOLSTICE including those requirements defined by the National Polar-orbiting Operational Environment Satellite (NPOESS). The SORCE spacecraft will be launched in July 2002.

The ESE is committed to provide a launch vehicle for the Canadian SciSAT mission. The Kennedy Space Center negotiated the launch vehicle contract in FY 2000. The launch vehicle build remains on track for a June 2002 launch.

QuikSCAT

The QuikSCAT mission, which is filling the ocean vector wind data gap created by the loss of the NASA Scatterometer (NSCAT) on the Japanese ADEOS I spacecraft, was launched from Vandenberg Air Force Base in June 1999. The Scatterometer data was released to the general science community on January 31, 2000. The reprocessing of all the data from the beginning of the mission, with improved rain flag and model function, was completed in July 2000. The Scatterometer has been operating for 19 months (as of January 2001), which is longer than any previous scatterometer. The prime mission will end on June 19, 2001. A continuation mission has been approved until September 30, 2002.

Landsat-7

The Landsat-7 satellite was launched on April 15, 1999, and declared operational in July 1999. The satellite continues to return excellent images, which meet or exceed NASA's expectations. First data was available to the public mid-August 1999. By agreement with the United States Geological Survey (USGS), NASA operated and funded operations in FY 2000. Landsat-7 is producing 150 Terabytes of data per day. Beginning in FY 2001, the USGS is operating and funding the Landsat-7 system.

EOS Follow-On

The next generation of EOS missions will provide new technology and space systems to meet the scientific needs for the NASA Earth science projects. NASA ESE has identified a mission architecture over the mid-term that will help achieve the specific scientific goals using a combination of systematic and exploratory missions. The new missions selected will capitalize on our investments in advanced technologies to reduce lifecycle time/cost and relate to longer-term scientific questions and practical applications. This architecture is directly related to the science priorities as outlined in the Science Implementation Plan. The approach to mission selection and implementation will assure maturity of key and essential technology during mission definition and formulation for both exploratory and systematic missions (i.e. no missions will go into implementation until key technologies are ready).
In FY 2001, new Follow On studies were initiated in the following areas: Landsat Continuity; Global Precipitation; Global Winds; Global Earthquake; and New Data and Information Systems and Services (New DISS).

As it deploys EOS, ESE is also planning for the future. For example, a Landsat Data Continuity Mission is being formulated in partnership with USGS, and will be implemented as a commercial data purchase if possible. ESE is also planning for the transition of several of its key research observations to the Nation's weather satellite system. The DoD, NOAA and NASA have established an Integrated Program Office (IPO) to create a converged civilian and military weather satellite system called the National Polar-orbiting Operational Environmental Satellite System (NPOESS) to replace the present generation of separate systems. NASA and the IPO are jointly funding the NPOESS Preparatory Project (NPP) that will simultaneously continue key measurements begun by EOS and demonstrate instruments for NPOESS. The NPP will save money for both organizations by combining essential atmospheric and Earth surface observations on a single platform, and by seeking to meet both climate science and operational weather requirements with the same advanced instruments.

The first set of <u>systematic</u> missions has been under formulation and study during the past year. These missions are:

- NPP "Bridge mission": Continues fulfilling our commitment to the science community for a 15-year data set for fundamental global climate change observations started by MODIS, AIRS, and a combination of AMSU/MHS/HSB, which are the primary instruments on the EOS Terra and Aqua satellites. This is also a shared cost precursor mission to the next generation of operational polar weather satellites being developed by the National Polar-Orbiting Operational Environmental Satellite

System (NPOESS) Integrated Program Office (IPO), a joint NASA, NOAA, DoD effort. This arrangement assures NASA's long-term science observational needs are met by the operational system.

- Landsat follow-on: Continues the basic global land cover change data set. We are hopeful this can be accomplished with a commercial data purchase or a government-industrial partnership, and released a Request for Information as a first step in exploring this avenue. We are in the process of developing a data specification and other formulation activities leading to a decision to proceed with solicitation development at the end of this year.

Other systematic missions that are currently being studied are:

- Global Precipitation: Observations from the Tropical Rainfall Measuring Mission have demonstrated the value of these data in modeling the global water and energy cycle, which is an emerging science theme for both the Enterprise and the U.S. Global Change Research Program. We are currently examining options for this mission. We are proposing to begin the formulation of this as the highest priority mission in FY 2002, and begin the international coordination with Japan and Europe.
- Ocean Altimeter: These data sets will lead to the next significant improvement in seasonal climate forecasts. One additional mission beyond Jason is required to ensure continuity before a transition to an operational satellite program is possible. We have the commitments from CNES and EUMETSAT in Europe and NOAA to carry on a transition mission from scientific research into a US/European constellation of polar orbiting satellites. The other three organizations have currently requested the required funds as part of their FY 2002 budget request to support this arrangement.
- Ocean Wind Vector: This mission is needed to provide continuity beyond Seawinds on ADEOS II (to be launched in 2002). Japan is offering a spacecraft and launch vehicle and the IPO has expressed interest in cost-sharing the instrument development and accommodation on behalf of the U.S. Navy and NOAA. We have commissioned a study to develop details to be completed by the end of the year. NASA considers this also to be a transition arrangement from scientific research into operations because NOAA, the Navy and EUMETSAT all have expressed interest in this data set based on QuikSCAT as part of their operational requirement.
- Solar Irradiance Monitor: These data provide the means to distinguish the external (solar) from internal sources of change in the Earth system. A follow-on mission is required to bridge the gap between the SORCE mission (2002) and NPOESS. Discussion with the NPOESS IPO will explore the potential for a shared mission or other mutually beneficial arrangement to meet this common requirement. Formulation activities for this mission concept will include exploration of such a partnership.
- Ozone/Aerosol Total Column: Total ozone measurements are required to assess the anticipated recovery of the ozone layer as a result of the Montreal Protocol. Aerosols are the largest source of uncertainty in efforts to quantify the forces acting on climate. TOMS currently provides the former (with Aura picking it up in 2003), and SAGE the latter. This combined mission is required to fill the gap between Aura & SAGE, and NPOESS.

SCHEDULE AND OUTPUTS

Preliminary Design Reviews - Confirms that the proposed project baseline is comprehensive (meets all project level performance requirements), systematic (all subsystem/component allocations are optimally distributed across the system), efficient (all components relate to a parent requirement), and represent acceptable risk.

Seawinds
Plan: May 1995
Actual: May 1995

Meteor-3M Stratospheric Aerosol & Gas Experiment (SAGE III)
Plan: July 1995
Actual: July 1995

Aqua (formerly PM-1)
Plan: April 1997
Actual: April 1997

Jason
Plan: June 1997
Actual: June 1997

ACRIM
Plan: March 1998
Actual: March 1998

ICESat (GLAS Instrument)
Plan: June 1998
Actual: June 1998

Aura (formerly Chemistry)
Plan: March 1998
Actual: October 1999

Rescheduled following completion of alternative configuration studies.

SORCE
Plan: May 1999
Actual: May 1999

SOLSTICE and TSIM were combined in FY 1999 to make the SORCE mission. The Mission Design Review and the Preliminary Design Review were combined and successfully conducted in May 1999.

NPP — Project in formulation. Revised due to schedule maturity.
Plan: December 2002
Revised: February 2002

Critical Design Reviews - Confirms that the project system, subsystem, and component designs, derived from the preliminary design, is of sufficient detail to allow for orderly hardware and software manufacturing, integration and testing, and represents acceptable risk. Successful completion of the critical design review freezes the design prior to actual development.

ACRIM:
Plan: January 1998
Actual: January 1998

Aqua (formerly PM-1) — Revised schedule due to late start following resolution of spacecraft award protest first reported in the 1998 budget
Plan: April 1998
Revised: June 1998

ICESat (GLAS Instrument)
Plan: March 1999
Actual: March 1999

Jason:
Plan: November 1998
Actual: November 1998

SORCE — Revised due to schedule conflicts.
Plan: October 2000
Actual: November 2000

Aura (formerly Chemistry)
Plan: August 2000
Actual: August 2000

NPP — Project in formulation. Revised due to schedule maturity.
Plan: December 2003
Revised: January 2003

Instruments Delivered - Confirms that the fabrication, integration, certification, and testing of all system hardware and software conforms to their requirements and is ready for recurring operation. Throughout system development, testing procedures or, as appropriate, engineering analysis have been employed at every level of system synthesis in order to assure that the fabricated system components will meet their requirements.

Landsat-7 Plan: December 1996 Actual: September 1998	ETM+ Instrument technical problems.
Terra last instrument Plan: February 1997 Actual: August 1997	Test anomalies occurred on the MOPITT instrument; which required rework by Canadians.
SAGE-III (Russian) Plan: December 1997 Actual: September 1998	Due to instrument and detector testing problems.
Seawinds Plan: March 1998 Actual: March 1999	Delayed due to launch slip by Japan.
Aqua (formerly PM-1) last instrument Plan: September 1999 Actual: December 1999	Instrument deliveries delayed, first reported in the 1998 budget
ICESat Plan: October 2000 Revised: June/July 2001	GLAS instrument delayed due to late vendor deliveries and development challenges.
Aura (formerly Chemistry) last instrument Plan: January 2002 Revised: July 2002	Rescheduled due to technical problems and 6-month launch delay.
QuikSCAT Plan: May 1998 Actual: May 1998	
ACRIM Plan: October 1998 Actual: June 1999	Instrument delivery changed to fit new launch schedule after selection of launch vehicle and spacecraft vendors.

Jason-1 Revised due to CNES spacecraft need date.
Plan: March 1999
Actual: September 1999

SORCE: TSIM and SOLSTICE were combined in FY 1999 to create the SORCE mission.
Plan: August 2001

NPP
Plan: October 2004

Algorithm Development (Version 2) - Confirms that the second version of the science software necessary for the production of the standard data products for each mission has been developed and is ready to support launch.

Terra
Plan: February 1998
Actual: February 1998

Aerosol SAGE-III (Russian) Commensurate with the delay in instrument delivery.
Plan: June 1999
Actual: March 2000

Seawinds
Plan: September 1998
Actual: September 1998

Jason-1 Revised due to delayed selection of science team and revised launch date.
Plan: October 1999
Actual: December 1999

Aqua (formerly PM-1)
Plan: July 2000
Actual: July 2000

Aura (formerly Chemistry) Revised to reflect change in LRD to 6/03.
Plan: December 2001
Revised: June 2002

ICESat
Plan: January 2001 — Revised due to launch delay.
Revised: May 2001

Launch Readiness Dates - Verifies that the system elements constructed for use, and the existing support elements, such as launch site, space vehicle and booster, are ready for launch.

Terra Plan: July 1999 Actual: December 1999	Due to RL10-11 A3 engine stand down, the Terra launch was delayed until the launch vehicles using RL-10-A3 engines were returned to a flight readiness status. Terra was successfully launched on December 18, 1999.
QuikSCAT Plan: April 1999 Actual: June 1999	Delayed due to USAF Titan IV failure investigations and launch site availability conflicts. QuikSCAT was successfully launched on June 19, 1999
Landsat-7 Plan: April 1999 Actual: April 1999	Landsat-7 was successfully launched on April 15, 1999.
ACRIMSAT Plan: November 1999 Actual: December 1999	ACRIMSAT was successfully launched on December 20, 1999.
Aerosol SAGE-III (Russian) Plan: September 1999 Revised: June 2001	Instrument integrated on the spacecraft and proceeding toward the scheduled launch date.
Seawinds (ADEOS-II) Plan: November 2000 Revised: TBD	Instrument delivered and integrated onto the spacecraft. Delay due to Japanese launch vehicle problem.
Jason 1 Plan: May 2000 Revised: NET June 2001	All NASA instruments were delivered to CNES in 1999. Delayed to accommodate satellite development by French Space Agency (CNES) partner.
Aqua (formerly PM-1) Plan: December 2000 Revised: NET July 2001	Launch delay caused by hardware failures during observatory integration and test.

Aura Plan: December 2002 Revised: July 2003	Directed launch slip to provide funding relief to other Earth Science Programs.
ICESat Plan: July 2001 Revised: December 2001	Budget cuts in early FY99 resulted in a launch delay to January 2002. The project continued to work toward an accelerated launch date of December 2001 due to the acquisition of the spacecraft bus through the RSDO development procurement mechanism. a
SORCE: Plan: July 2002	TSIM and SOLSTICE were combined in FY 1999 to the SORCE mission.
NPP Plan: December 2005	

ACCOMPLISHMENTS AND PROPOSED RESULTS

Terra

The Terra spacecraft opened its aperture doors on February 24, 2000 beginning its science operations. Terra Level-1 data products from MODIS and CERES were released 4 months after launch with spacecraft checkout completed by April 2000. Terra collects 200 gigabytes (200,000 megabytes) of data per day over the entire globe. Among the first operational uses of Terra was imagery from the MODIS instrument in support of the U.S. Forest Service to combat the western U.S. forest fires this past summer. The images from MODIS assisted fire fighters in identifying the active locations of the fire(s) itself instead of through smoke-filled images, and allowed them to control the rapidly spreading fires. MODIS imagery was also used by the Geography Department at Dartmouth College in New Hampshire to assist in flood hazard reduction programs. MODIS data also supports geographic information that Dartmouth converts and distributes to disaster relief agencies through the World Wide Web.

In January 2001, Popular Science Magazine voted Terra to receive the “Best of What’s New” Award in its Aviation and Space Category as being best in innovation for the year 2000.

In FY 2001 Terra Level-2 and above products will be released as the first round of product validation efforts completed by instrument science teams. In FY 2002 Terra will continue its mission operations and continue to provide state of the art imagery to the science community to help in the evaluating and analysis of changing Earth.

Aqua

During FY 2000, integration and test of the observatory continued with successful dynamic tests. Failures in the Formatter Multiplexor Unit (FMU)/Solid State Recorder (SSR), and problems with the Transponder and Transponder Interface Electronics (TIE) have delayed the launch readiness to no earlier than July 2001. All instruments have been integrated with the spacecraft.

Observatory and instrument checkout will occur for approximately 120 days after launch after which nominal mission operations will commence.

Aura

The Aura mission focuses on the impact of greenhouse gases on the global climate. In FY 2000, the Aura Project successfully completed a delta Preliminary Design Review and a delta Critical Design Review of the EOS common spacecraft design to verify the Aura unique aspects of the spacecraft development. Also, the spacecraft began bus level integration. In addition, the Ozone Monitoring Instrument successfully completed their delta CDR. Assembly and test of the spacecraft bus units will be completed and bus integration will begin in FY 2001. In FY 2002, all of the instruments will be delivered and integrated onto the spacecraft, and observatory level testing will begin. The launch of Aura is scheduled for no earlier than June 2003.

Special Spacecraft

Jason

The Jason MOU between NASA and CNES was signed in December 1996. CNES will provide the spacecraft, solid-state altimeter, and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) positioning system. NASA will provide the microwave radiometer, Global Positioning System (GPS) and laser retroreflector array. The ground system and mission operations will be shared. NASA will also provide the launch services. Delays in the CNES satellite development program have caused the launch of Jason to be rescheduled. NASA supported a Jason-1 PDR in June 1997 and initiated the Boeing Delta II launch vehicle contract in September 1997.

CNES held the system-level CDR for the Jason mission with NASA support in the fall of 1998. Simulators or engineering models of all the instruments were delivered to CNES, who will perform platform and payload integration and test as separate activities. The flight models of all the instruments were delivered by September 1999. Satellite-level integration and test began in late 1999 with significant portions of system-level testing completed in FY 2000. A Satellite Qualification Review was conducted in November 2000 with participation by the NASA independent review team (Red Team). CNES will ship the integrated satellite for Jason to the Western test range and launch is co-manifested with NASA's TIMED space science satellite. Launch was initially scheduled for May 2000 on the Delta Launch vehicle but is being rescheduled for no earlier than June 2001 due to continuing CNES satellite development problems. After launch and a 60-day checkout, normal mission operations are scheduled to begin, including formation flying with the TOPEX/Poseidon satellite, to provide cross correlation for scientific trend analysis of the sea-surface height.

ICESat

The ICESat team successfully completed the Mission Design Review (MDR) in March 2000 and the vehicle Dual Payload Attached Fitting (DPAF) Critical Design Review (CDR) in July 2000. Critical activities for FY 2001 include integration and test of the GLAS instrument with the spacecraft and launch vehicle integration in preparation for launch. ICESat will launch in early FY 2002 with a 120-day calibration/validation period; generation of data products will also begin in FY 2002.

SORCE

The SORCE team successfully completed both the PDR and the CDR for the spacecraft bus in FY 2000. Additionally, the Mission CDR was successfully completed in November 2000. The SORCE instruments completed their development and design phase in FY 2000 and have transitioned into flight fabrication and test. Even though there have been some delays in the various phases of the instrument development, the SORCE instrument suite is still on schedule to be completed in August 2001. In FY 2000, KSC selected the Pegasus launch vehicle for the SORCE Mission and established the launch services contract with Orbital Sciences Corporation (OSC). Key milestones for FY 2001 include the Mission Operations Review in April 2001, completion of the integration of the SORCE instruments on to the optical bench in August 2001, and completion of the spacecraft bus integration in August 2001.

SAGE

Three SAGE-III instruments were manufactured for long-term monitoring of ozone and aerosols. All three instruments have been delivered. The first instrument is presently in Russia integrated on the Meteor spacecraft proceeding toward a June 2001 launch. The second instrument is undergoing testing and is planned to fly on the International Space Station (ISS) in 2005. The third instrument is planned for flying on a joint mission with Argentina.

SeaWinds

The SeaWinds protoflight model was delivered to Tsukuba, Japan in March 1999 for a launch on the ADEOS II spacecraft by a NASDA H-IIA rocket from Tanegashima, Japan. The spacecraft is integrated and has completed thermal vacuum, acoustic, vibration, pyro-shock and post-dynamic electrical testing. In addition, mass properties and alignment measurements were completed in November 2000. The spacecraft is currently scheduled for launch in 2002.

ACRIMSAT

The Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSAT) was successfully launched from Vandenberg Air Force Base (VAFB) on December 20, 1999. The spacecraft was manifested on a Taurus launch vehicle with the Korean Multipurpose Satellite (KOMPSAT). The Mission and Operations Readiness Review and Risk Assessment Review were completed on November 29, 1999 at VAFB. The spacecraft was initially operated from the Orbital Sciences Spacecraft Operations Control Center (SOCC) in Dulles, VA. After a successful on-orbit checkout in April 2000, spacecraft operations using the ACRIMSAT ground station located at JPL's Table Mountain Observatory in Wrightwood, CA was taken over by JPL. ACRIMSAT is gathering 18 percent more data than specified in mission requirements and providing the best Total Solar Irradiance (TSI) measurements to date.

QuikSCAT

The QuikSCAT mission, which is filling the ocean vector wind data gap created by the loss of the NASA Scatterometer (NSCAT) on the Japanese Advanced Earth Observing Satellite (ADEOS I) spacecraft, was launched from Vandenberg Air Force Base on June 19, 1999. The Scatterometer data were first released to the general science community on January 31, 2000. The reprocessing of all the data from the beginning of the mission, with improved rain flag and model function, was completed in July 2000. The Scatterometer has been operating for 19 months (as of January 2001), which is longer than any previous scatterometer. The prime mission will end on June 19, 2001. A mission extension has been approved until September 30, 2002.

Landsat-7

The Landsat-7 satellite was launched on April 15, 1999, and declared operational in July 1999. The satellite has been returning excellent images, which meet or exceed NASA's expectations. First data were available to the public in mid-August 1999. By agreement with the USGS, NASA operated and funded operations in FY 2000. Beginning in FY 2001, the USGS operates and funds the Landsat-7 system.

EOS Follow-On

NASA ESE has developed a science implementation plan, which will drive the selection of EOS follow-on missions. Two of those missions were included in the 2001 budget request: NPP and Landsat follow-on. Studies have also been initiated in FY 2001 for Global Precipitation, Global Winds, Global Earthquake and New DISS activities.

The NPP completed initial spacecraft studies in FY 2000, and will award contracts for more detailed studies in FY 2001. The Advanced Technology Microwave Sounder (ATMS) instrument detailed study contract were completed in FY 2000 and the implementation contract was awarded in FY 2001. A joint NASA/IPO NPP Mission Systems design review was successfully conducted in FY 2001. The tentative launch readiness date is late 2005. At present, NASA is responsible for spacecraft development and integration; one instrument, the Advanced Technology Microwave Sounder (ATMS); overall mission integration; launch vehicle (including support and early checkout); and science data processing. The IPO is responsible for two instruments, Visible Infrared Imaging Radiometer Suite (VIIRS) and the CRoss-track Infrared Sounder (CRIS); ground system development; flight operations; and operational data processing.

Landsat follow-on: Continues the basic global land cover change data set. NASA is hopeful this can be accomplished with a commercial data purchase. A Request for Information has been released as a first step in exploring this avenue. In addition, workshops have been and will be held with potential industry, government and commercial partners to further define the process to enable a commercial data policy.

Formulation will be initiated in FY 2002 for Global Precipitation, Ocean Topography, Ocean Wind Vector. Studies will include those for Solar Irradiance Monitor, and Total Column Ozone.

BASIS OF FY 2002 FUNDING REQUIREMENT

EARTH OBSERVING SYSTEM DATA INFORMATION SYSTEM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Earth Observing System Data Information System............	278,880	281,391	252,650

PROGRAM GOALS

The goals for the EOS Data and Information System (EOSDIS) are the development and operation of a system which can: (1) operate the EOS satellites; (2) acquire instrument data; (3) produce data and information products from the EOS and other Earth Sciences Enterprise data holdings; (4) preserve these and all other Earth science environmental observations for continuing use; and (5) make all these data and information easily available for use by the user community. The EOSDIS facilitates the goals of Earth science by enabling the public to benefit fully from increased understanding and observations of the environment.

STRATEGY FOR ACHIEVING GOALS

The EOSDIS is currently supporting an array of satellites by providing mission operations, data capture, data production, data archive, data distribution, and user support. This system is designed to evolve over time as the data sources, missions, technologies, and user needs change. This has been effected, through the use of a combination of specialized core systems, user specific systems for instruments or scientific disciplines, commercial off-the-shelf items, and cooperative activities with heritage data centers to ensure continued support to established user communities. In addition, the expansion of data services is encouraged through cooperation with the Distributed Active Archive Centers (DAACs,) Earth Science Information Partners (ESIPs), Regional Science Applications Centers (RESACs), and the Synergy Program. The EOSDIS sustains a partnership with NOAA, USGS, and international partner space agencies.

The EOSDIS development has been divided into six major components:

1. The Polar Ground Stations (PGS) which provide command uplink and telemetry downlink. The PGS are now part of the Ground Network (GN), managed by SOMO and the focus of a major SOMO commercialization effort;
2. The EOS Data and Operations System (EDOS) which receives the raw data stream from the satellites, separates the data by instrument, and performs the initial processing (packet restoration and temporal ordering) and back-up archiving. EDOS interfaces to the TDRSS ground terminal at the White Sands Complex for Terra data, and will interface to the PGS in Alaska and Norway for data from the Aqua, ICESat and Aura missions. The raw data collected from the satellites are sent to the EDOS Level-0 processing center at GSFC, which processes the data and sends them via EBNet to the DAACs and the Science Investigator-led Processing Systems (SIPS);

3. The EOSDIS backbone Network (EBNet) which delivers the real-time data to and from the mission operations control centers and the science data to the DAACs and SIPS. EBNet was originally developed by GSFC, but is now managed as part of SOMO/NISN;
4. The EOSDIS Core System (ECS) includes the Flight Operations Segment (FOS), which provides command and control capabilities to operate the EOS spacecraft (the present implementation of FOS is called the EOS Mission Operations System (EMOS)), and the Science Data Processing Segment (SDPS) which provides data product generation using science software provided by the Principal Investigators (PIs), data archiving, and distribution. The SDPS is operated at the DAACs;
5. The DAACs, which produce EOS standard data products using algorithm software provided by the PIs, archive data, and distribute these data to end users. Each DAAC focuses on the data needs of a specific segment of the user community, with User Working Groups advising individual DAACs. The eight DAACs are:
   - Alaska Synthetic Aperture RADAR (SAR) Facility, Geophysical Institute, University of Alaska, Fairbanks, Alaska
   - Earth Resources Observation System (EROS) Data Center (EDC), U.S. Geological Survey, Sioux Falls, South Dakota
   - Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
   - Langley Research Center (LaRC), Hampton, Virginia
   - National Snow and Ice Data Center (NSIDC), University of Colorado, Boulder, Colorado
   - Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee
   - Socio-Economic Data and Applications Center (SEDAC), Lamont-Dougherty Earth Observatory, Columbia University, Palisades, New York
   - Goddard Space Flight Center, Greenbelt, Maryland
6. The SIPS provide data product generation at Instrument Team sites, and send the data via EBNet to the appropriate DAAC for archiving and general distribution. The SIPS produce data products in a way that takes advantage of the latest technologies and the instrument teams' expertise.

EOSDIS relies also on other agencies (such as USGS which manages the Landsat Data Processing system) and other countries (such as Japan for the ASTER science data production). EOSDIS allows direct access to data acquired from EOS satellites, selected pathfinder data holdings from the USGS and NOAA, and other heritage and ancillary data. Relationships with Canada, Japan, Russia, Israel, Australia and several European countries have been established for the exchange of data with EOSDIS. Many multi-agency efforts, in addition to the NASA EOSDIS, are working to improve data availability to the public, especially the Interagency U.S. Global Change Research Program (USGCRP) Data and Information Working Group and the Federal Geographic Data Committee.

NASA is looking to future data system needs and designs in several ways. The EOSDIS Working Prototype Federation experiment, initiated in 1998, is continuing to develop methodologies for decision making and interoperability in a collaborative, yet competitive, distributed data system topology. Members of the Federation represent the broad scientific and applications community and include representatives from educational institutions, industry, regional governments and consortia, and NASA data centers. NASA is also engaged in long-term planning for the evolution of the current Earth science data system. This New Data Information Systems and Services (NewDISS) comprises a distributed Earth science data system, which, over the next 6-10 years, will evolve from the current EOSDIS. NewDISS is planned to consist of a heterogeneous mix of interdependent components of numerous individuals and institutions. Because the ESE already has made a considerable investment in existing data system components (e.g., DAACs, ECS, SIPS, and ESIPs), as well as product generation, the near-term NewDISS will necessarily evolve from these existing activities. The long term NewDISS structure could be quite different from the current, as data systems and services evolve to meet science-driven demands and to take advantage of technological innovation.

SCHEDULE AND OUTPUTS

EOSDIS Version 1 Plan: January 1997 Revised: Replaced	Provide support for science data processing, archival, and management of the data from the two EOS instruments operating on the TRMM spacecraft. The ECS contractor failed initial test readiness for EOSDIS Version 1 and NASA issued a Stop Work Order. Replacement systems were developed by EOSDIS at GSFC and LaRC, (extended "Version 0" in-house system), and the systems are performing successfully.
EOSDIS Version 2 Plan and actual: January 1999 through December 1999	Provide support for the launch of Terra and Landsat-7. The capabilities to meet the requirements were provided in a set of incremental deliveries beginning in January 1999 and ending in December 1999. EOSDIS Version 2 is successfully supporting operations of the Landsat-7 and Terra missions
EOSDIS Version 3 Plan: June 2000 Revised: December 2000	Provide science processing and flight operations support for Aqua and ICESat. EOSDIS components needed to meet the objectives of Version 3 are ready; integration and end-to-end testing are being carried out to match Aqua and ICESat launch schedules.
EOSDIS Version 4 Plan: December 2000 Revised September 2002	Provide science processing and flight operations support for Aura. Provide final incremental implementation of ECS A+ requirements. Schedule adjusted commensurate with Aura launch schedule.

ACCOMPLISHMENTS AND PROPOSED RESULTS

Providing broad and efficient access to data products is key to meeting the Agency's mission of advancing and communicating scientific knowledge and the successful functioning of EOSDIS is essential to the accomplishment of all three of the ESE's strategic goals. EOSDIS has been routinely providing and will continue to provide Earth science data products to end-users within 5 days of receipt of request or following production of the requested data product. These products comprise data from currently operating space assets including interdisciplinary data products from the Terra mission, land cover information from the Landat-7 satellite, ocean wind measurement from the QuikSCAT mission, precipitation measurements and observations of tropical storms from the Tropical Rainfall Measurement Mission (TRMM), ocean productivity measurements from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS), detection of ocean surface height changes used to predict El Nino occurrence and strength from the Topex/Poseidon Mission, solar energy input to the Earth from ACRIMSat, and sea ice motion and Antarctic mapping from Canada's RADARSAT. Also provided are measurements on stratospheric dynamics and trace chemicals from the Upper Atmospheric Research Satellite (UARS), the Antarctic Ozone Hole from the Total Ozone Mapping System (TOMS), land use and land cover from the heritage Landsat missions, and measurements of Earth and solar radiation from the Earth Radiation Budget Experiment (ERBE).

The EOSDIS is currently supporting an unprecedented amount of data and information. As a comparison, the EOSDIS effectively handles in one day more Terra data than the Hubble Space Telescope handles in a year or than the Upper Atmospheric Research Satellite (UARS) handles in 1.5 years. Some key indicators of EOSDIS performance are the volume of data archived (over 500 Terabytes at the end of FY 2000, including heritage data), the number of users accessing the DAACs (just under 1.47 million distinct users in FY 2000), and the number of data products delivered in response to user requests (approximately 8.1 million data products delivered in FY 2000). In the past year alone, the EOSDIS has supported a doubling of the entire NASA Earth science data holdings.

The ECS FOS supported a December 1999 launch of the Terra spacecraft and has successfully supported the Terra spacecraft and instrument operations through 2000. ECS FOS capabilities were extended to support Aqua spacecraft and instrument requirements, and ECS FOS successfully demonstrated these capabilities in a number of tests with the Aqua spacecraft conducted during 2000. The FOS Instrument Support Terminals (ISTs), which allow instrument operations teams to plan for the operation of their instruments and monitor instrument performance from their home institutions, are installed and are operational at all operations sites for the Terra instrument teams. ISTs have been installed at the major U.S. operations facilities in support of the Aqua spacecraft and instruments.

Other elements of EOSDIS are continuing to support the Terra mission. The EDOS overcame early problems with processing and distributing Terra science data (not unusual for a new mission of this complexity) and is successfully managing the Terra science data. Upgrades of EDOS to support Aqua and ICESat will become operational in mid FY 2001. The EBNet and Polar Ground Stations are satisfactorily supporting Terra operations (PGS is backup to TDRSS for Terra) and have made the necessary upgrades and enhancements to support the Aqua mission.

Development of the ECS SDPS has progressed well, and this segment achieved stable operations for Terra in 2000. The data are being processed at better than “keep-up” rates, data from the SIPS are being ingested, and all processed data are being archived and are available for distribution. The DAACs also continued to support the Landsat-7 mission. By the end of FY 2000 the DAACs had amassed close to 250 Terabytes of data from the Landsat-7 and Terra missions. The Terra Instrument Science Teams began planning for the first reprocessing of the Terra science data sets in FY 2001. System upgrades were made to improve user interface services, to add capabilities required for support of Aqua instruments, increase system capability, and to update to newer versions of Commercial-Off-The-Shelf (COTS) products. The Performance Verification Center (PVC) was established to provide an environment for testing fully loaded performance of new releases, prior to deployment to operational DAACs.

In FY 2000, the ECS contract was restructured, scaling back on some lower priority requirements, and adding new requirements for support of future missions such as Aqua, ICESat, and Aura. A sound cost baseline was established and the contractor has been performing well against this revised baseline.

The ECS Science and Flight Operations Segments were both verified to be compliant with Y2K in FY 2000 and encountered no problems with the year rollover. They received authority to process in December 2000, in accordance with the NASA Policy and Guidance (NPG) 2810.1 that mandates Information Technology (IT) security requirements for NASA data and systems. System changes to achieve full compliance with NPG 2810.1 will be made in FY 2001.

The evaluation, started in FY 1999, of proposals from all the EOS instrument teams interested in producing standard products using SIPS was completed in FY 2000. With four exceptions all of the instrument teams (including those for all instruments on Aura) have chosen to produce all standard products using SIPS. The MISR team on Terra and the AIRS team on Aqua generate their products using the SDPS at DAACs. The MODIS team (on Terra and Aqua) generates Level 1 products and a small number of Level 2 products at the GSFC DAAC, with the rest being produced at their SIPS. In addition, ASTER Level 1 data are produced in Japan and shipped to the EDC DAAC, where higher-level products are produced.

The EOSDIS Federation experiment continued in FY 2000. Federation members developed a constitution and bylaws and are establishing the rules and requirements for membership. The Federation now consists of 24 ESIPs, the eight DAACs and one EOS science computing facility (SCF). Twelve ESIPs focus on research, and science data set production and management while the remainder focus on commercial and extended applications. These groups are developing scientific products, collaborating with one another, both as single entities and in "clusters", and collectively exploring data set interoperability.

NASA is continuing the long term planning for the evolution of the current Earth Science data system. A team of Earth and information scientists along with NASA managers developed a concept for the NewDISS, which will evolve from the current EOSDIS, the working prototype Federation experiment, and other ESE mission data systems.

The EOSDIS Core System (ECS) software deliveries are planned in FY 2001 to support requirements for the Aqua, Aura, and ICESat missions, and operations readiness testing will ensure that all systems are ready and able to support the Aqua and ICESat launches planned within the next year. Capabilities will be developed for people to create their own clients for searching and ordering data. The EOSDIS will continue to work to meet its planned performance targets. Indicators of this activity will be to continue making data available to users within 5 days of request and improving on prior year targets for archive, distribution, and number of customers served. The primary tasks in FY 2002 will be the operation and completion of the EOSDIS.

BASIS OF FY 2002 FUNDING REQUIREMENT

EARTH EXPLORERS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Total Ozone Mapping Spectrometer	24,508	69	40
Earth System Science Pathfinders	90,000	111,598	84,013
VCL	*18,965*	*13,706*	--
GRACE	*24,632*	*16,113*	*6,500*
PICASSO-CENA	*24,783*	*26,399*	*29,130*
CloudSat	*19,137*	*47,625*	*37,670*
Program Support/Future missions	*2,483*	*7,755*	*10,713*
Experiments of Opportunity	1,000	499	500
Triana	35,100	24,934	--
University Class Earth System Science	2,292	475	--
Shuttle Radar Topography Mission	10,200	3,662	--
Total	163,100	141,237	84,553

PROGRAM GOALS

The name of the program has been changed from Earth Probes to align itself with the exploratory measurement definition/concept. The Earth Explorers Program is the component of Earth Science Enterprise that investigates specific, highly focused areas of Earth science research. It is comprised of flight projects that provide pathfinder exploratory and process driven measurements, answering innovative and unique Earth science questions. The program has the flexibility to take advantage of international cooperative efforts. It provides the ability to investigate processes having unique measurement requirements and which call for quick turnaround and reaction. The Earth Explorers missions consist of the Total Ozone Mapping Spectrometer (TOMS) series, the Earth System Science Pathfinders (ESSP) missions, the University Class Earth System Science (UnESS) pathfinders, Experiments of Opportunity, SRTM and Triana.

STRATEGY FOR ACHIEVING GOALS

TOMS

The scientific objectives of the TOMS project are to measure the long-term changes in total ozone and to verify the chemical models of the stratosphere used to predict future trends. The TOMS flights build on the experience that began in 1978 with the launch of a TOMS instrument (flight model 1) on Nimbus-7 and continued with the TOMS instrument (flight model 2) on a Russian Meteor-3, launched in 1991, a TOMS (flight model 3) launched on the Japanese ADEOS in 1996 and the Earth Probe spacecraft also launched in 1996. The development of a fifth TOMS instrument flight model 5, designated FM-5 has been completed, and was scheduled to fly as a cooperative mission with Russia in late 2000. However, in 1999 Russia indicated that it could not meet that launch date. Presently, the Agency has completed its re-planning and will fly FM-5, on a dedicated spacecraft mission called QuikTOMS. The QuikTOMS spacecraft was procured through the Indefinite Delivery Indefinite Quantity (IDIQ) rapid delivery spacecraft contract. The QuikTOMS observatory will be launched from Vandenberg Air Force Base as a secondary payload on a commercial Taurus launch vehicle in June 2001.

ESSP

The ESSP is a science-driven program intended to identify and develop in a relatively short time, small satellite missions to accomplish scientific objectives in response to national and international research priorities not addressed by current projects. ESSP will provide periodic "windows of opportunity" to accommodate new scientific priorities and infuse new scientific participation into the Earth science program. By launching ESSP missions on a regular basis, NASA will provide a mechanism by which pressing questions in Earth system science may be addressed in a timely fashion, permitting a continual improvement in our understanding of the Earth system and the processes that affect it.

The first two ESSP missions were selected in March 1997. The Vegetation Canopy Lidar (VCL) mission, led by a University of Maryland, College Park Principal Investigator, is being designed to utilize a multi laser Light-Detection and Ranging (Lidar) instrument to map the vegetation canopy globally. The VCL mission is under replan. The VCL launch date is TBD. The second mission, Gravity Recovery and Climate Experiment (GRACE) is led by a Principal Investigator from the University of Texas at Austin with significant participation by the German Aerospace Center (DLR), which is providing mission operations, launch services and science data analysis. GRACE will utilize an advanced microwave ranging system between two identical formation flying spacecraft to measure the Earth's gravitational field to an unprecedented accuracy. The planned launch date of GRACE on a contributed ROCKOT launch vehicle is November 2001.

The second ESSP Announcement of Opportunity (AO) was released in the third quarter of FY 1998. The Pathfinder Instruments for Cloud and Aerosol Spaceborne Observations – *Climatologie Etendue des Nuages et des Aerosols* (PICASSO-CENA) mission, which was selected in December 1998, is led by a NASA LaRC Principal Investigator. The PICASSO-CENA mission is under replan and the launch date is TBD. PICASSO-CENA is designed to address the role of clouds and aerosols in the Earth's radiation budget. It will employ innovative Lidar instrumentation to profile the vertical distribution of clouds and aerosols. PICASSO-CENA consists of a partnership between NASA and France's Centre Nationale D'Etudes Spatiale (CNES). CNES is providing a PROTEUS spacecraft, the imaging infrared radiometer (IIR), payload-to-spacecraft I&T and spacecraft mission operations. In addition, under this second ESSP AO NASA chose two additional missions, CloudSat and the Volcanic Ash Mission (VOLCAM), for further study. Based on the study results completed in March 1999, NASA selected CloudSat for full development as an ESSP AO#2 mission. VOLCAM was selected as the alternate mission, but was discontinued in 2000 based on the formulation progress of PICASSO and CloudSat. CloudSat, led by a Colorado State University Principal Investigator, is designed to advance the understanding of the cloud-climate feedback question. The mission is focused on understanding the role of optically thick clouds on the Earth's radiation budget using an advanced Cloud-Profiling Radar instrument, and is expected to be launched on half a Delta in 2003. CloudSat is a collaboration between NASA, the Canadian Space Agency (CSA), and the U.S. Air Force; CSA is contributing instrument components and the U.S. Air Force is contributing ground operations.

NASA intends to solicit another set of ESSP missions via ESSP AO #3 in calendar year 2001.

Experiments Of Opportunity

This project offers a capability to undertake short duration flights of instruments on the Space Shuttle and other platforms. The ESE has used the capability of Shuttle/Spacelab development in the important areas of design, early test and checkout of remote sensing instruments for free flying missions, and short-term atmospheric and environmental data gathering for scientific analysis. Instrument development activities have supported a wide range of instrumentation, tailored for Space Shuttle and airborne missions.

Triana

The Triana mission is an Earth observation spacecraft to be located at the Sun-Earth L1 point providing a near-term real time, continuous scientific observations of the full sun-lit disc of the Earth.

During 1998 the mission was studied at GSFC and NASA Headquarters released an AO in July soliciting proposals for full Triana mission implementation. A selection was made in November for the Scripps Institution of Oceanography to build and conduct the Triana mission. Triana is designed to carry the Earth Polychromatic Imaging Camera built by Lockheed Martin Advanced Technology Company, a radiometer built by the National Institute of Standards and Technology, and a plasma magnetometer that measures solar wind built by GSFC and the Massachusetts Institute of Technology. In October 1999, the Triana mission suspended work per Congressional direction, while the National Academy of Science (NAS) conducted its review of the scientific merits of the mission. In April 2000, after a favorable finding, work was restarted. However, the stand down resulted in a delay of the launch readiness date of no earlier than April 2002. Because the launch date for Triana remains uncertain until the Shuttle manifest becomes definitized, Triana will be placed in storage following completion of spacecraft development.

UnESS

UnESS was to consist of spaceborne investigations of modest science scope. These investigations were to be lead by U.S. University principal investigators with significant student involvement. The first Announcement of Opportunity was released in August 1999, and resulted in the award of four Phase A studies. The program is being cancelled to fund immediate priorities in the Earth Science budget. A small amount of funding will be retained for these activities to complete contractual obligations associated with proposal evaluations.

SRTM

The Shuttle Radar Topography Mission (SRTM) flown on STS-99 in February 2000, was a joint National Aeronautics and Space Administration (NASA) and National Imaging and Mapping Agency (NIMA) mission which collected an unprecedented 8 Terabytes of interferometric Synthetic Aperture Radar (SAR) data (equivalent to about 12,300 CDs). This data will be processed to provide topographic data products over approximately 80% of the Earth's landmass (between 60° North and 56° South latitude).

Development, integration and test, and checkout of the complex, first-of-a-kind processing system will take 19 months, from February 2000 to August 2001. Subsequent production of the topographic products will take 9 months, from September 2001 to May 2002.

SCHEDULE AND OUTPUTS

Launch Readiness dates – verifies that the system elements constructed for use, and the existing support elements, such as launch site, space vehicle and booster, are ready for launch.

TOMS FM-5 (QuikTOMS) Plan: August 2000 Revised: June 2001	QuikTOMS is co-manifested as a secondary payload with Orbview 4. Orbview 4, the primary payload, is experiencing integration and test difficulties, which are causing a launch delay.
Vegetation Canopy Lidar (VCL) Plan: May 2000 Revised: TBD	The initial launch delay was due to a launch vehicle change from a Pegasus to an Athena. Further delays in instrument and spacecraft bus development have led to the additional TBD launch delay. The Athena I originally designated to launch VCL from Kodiak Island, Alaska will now launch the KODIAK Star payload compliment. A new launch vehicle has not been selected for VCL. New launch date is under review.
Triana Plan: December 2000 Revised: TBD	Congressional mandated work suspension resulted in Triana being unable to support the previously assigned STS launch. Re-manifesting has resulted in TBD launch date.
Gravity Recovery and Climate Experiment Plan: June 2001 Revised: November 2001	Re-planned launch date reflects delays in flight software and instrument development.
PICASSO-CENA Plan: 2nd Qtr FY 2003 Revised: TBD	Based on findings from the PICASSO-CENA Mission Confirmation Readiness Review, the program was directed to postpone the final confirmation decision. PICASSO is expected to conduct a Delta Confirmation Readiness Review in March 2001, at which time a launch date will be determined.
CloudSat Plan: 2nd Qtr FY 2003 Revised: 3rd Qtr FY 2003	In November 2000 CloudSat successfully completed the confirmation review process which resulted in a launch readiness date of the Third Quarter FY 2003.

ACCOMPLISHMENTS AND PROPOSED RESULTS

TOMS

The QuikTOMS (TOMS FM-5) instrument has been completed and delivered for observatory integration. The QuikTOMS spacecraft bus is currently in integration and test. The QuikTOMS observatory is expected to be able to support the LRD as dictated by Orbview 4, the primary payload.

ESSP

VCL is in the process of being re-baselined and a new LRD will be determined once this process is complete. The Multibeam Laser Altimeter (MBLA) instrument is in development having fully characterized the flight laser design, while the spacecraft bus is in an Integrated System Test. GRACE instrument deliveries are nearly complete, the two spacecraft buses are complete and system level testing will begin in February 2001, with a scheduled launch of November 2001. PICASSO-CENA has completed its preliminary design review and is in the mission confirmation process with implementation expected to begin in April 2001. CloudSat completed formulation in December 2000 and is in implementation with a critical design review scheduled for August 2001. The third ESSP AO draft has been released for comment and the final announcement is expected to be released in 2001.

Experiments of Opportunity

The Experiments of Opportunity Program is the funding source for NASA's participation in the *Satellite de Applicaciones Cientificas-C* (SAC-C) mission. SAC-C is a joint mission between NASA and the Argentine Space Agency (CONAE). The mission was co-manifested with NASA's New Millennium Earth Orbiter-1 mission and was launched November 21, 2000. NASA provided the launch vehicle, scalar helium magnetometer and GPS receivers. The Argentines provided the spacecraft and various instruments such as multispectral scanner, and high-resolution camera. Calibration/validation was completed in the First Quarter of 2001.

TRIANA

Both the spacecraft and instruments have been assembled and are nearing completion of environmental test. The work on the spacecraft and instruments will be completed, and documented prior to storage.

BASIS OF FY 2002 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Earth Science Program Science	286,399	350,626	357,453
Applications, Commercialization and Education	84,400	114,081	--
Applications, Education, and Outreach (FY 2002 and out)			63,200
Technology	94,515	114,951	96,000
Construction of Facilities..	1,000	--	--
Total..	466,314	579,658	516,653

PROGRAM GOALS

The goal of Research and Technology is to advance our understanding of the global climate environment, the vulnerability of the environment to human and natural forces of change, and the provision of numerical models and other tools necessary for understanding global climate change.

STRATEGY FOR ACHIEVING GOALS

The Research and Technology program is divided into three components:

- Research that supports basic Earth science research, analysis, and data analysis of related EOS and other mission science data. Included is the suborbital science program of crewed aircraft and uninhabited aircraft available to researchers and PIs. There is both disciplinary-oriented science that typically focuses on one component or process of the Earth system and interdisciplinary science that emphasizes the linkages between Earth system components. Also included are funding for high performance computing and communications, and the provision of computing infrastructure.

- Applications, Education and Outreach that supports applications program planning and analysis, research, development, and the transfer of knowledge and awareness of ESE science and technology applications through education and outreach in the areas of disaster management, resource management, environmental quality and community growth.

- Earth Science advanced technology that supports development of key technologies to enable our future science missions by reducing their development time and cost.

Each of the major components of Research and Technology has its own set of goals, strategies for achieving goals, performance measures, and accomplishments and plans.

BASIS OF FY 2002 FUNDING REQUIREMENT

EARTH SCIENCE PROGRAM SCIENCE

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Research and Analysis – Science	141,849	170,225	167,922
EOS Science	55,000	48,393	54,341
Mission Science Teams - Research	55,850	96,188	94,590
Airborne Science and Applications	23,100	22,649	23,000
Uncrewed Aerial Vehicles (UAV)	3,000	3,492	4,000
Information Systems	7,600	9,679	13,600
Total	286,399	350,626	357,453

PROGRAM GOALS

Earth science research is driven by the hierarchy of scientific questions defined in the Earth Science Research Strategy for 2000-2010. The program goal is to contribute to the development of an improved scientific understanding of the Earth system and the effects of natural and human-induced variations on the global environment. The science program provides the analysis and integration of critical data and models needed to characterize the variability in the earth system and the natural and human-induced forcing factors that affect it; to understand the process by which the Earth system responds to forcing; the regional and global consequences of Earth system variability; and to develop the predictive capability for the Earth system.

STRATEGY FOR ACHIEVING GOALS

The Research and Analysis (R&A) science project is essential to the discovery of new concepts and techniques and serves as the ultimate source of scientific advances that lay the ground work for future satellite missions. The primary mode of research coordination and planning occurs through cooperation under the USGCRP, overseen by the Committee on the Environment and Natural Resources (CENR) Subcommittee on Global Change Research, and the various boards and committees at the National Academies of Sciences. NASA ESE manages its R&A budget largely according to five theme areas: Biology and Biogeochemistry of Ecosystems and the Global Carbon Cycle, Atmospheric Chemistry, Aerosols and Solar Radiation, Global Water and Energy Cycle, Oceans and Ice in the Earth System, and Solid Earth Science. There is also a strong emphasis on assuring an appropriate environment to nurture interdisciplinary science. The Natural Hazards portion of this latter area is addressed under the Applications, Education and Outreach program.

The aim of Earth system science is to increase scientific understanding of the global environment and its vulnerability to both human and natural factors of change (e.g. pollution, climate variability, and deforestation). Viewing the Earth from space is essential to comprehending the combined influence of human activities and natural variability on its global natural resource base. An important priority is to provide accurate assessment of the extent and health of the world's forest, grassland, and agricultural resources. Observations from space are the only source of global-scale objective information on the human use of land in a time of rapid land use development. Another priority is to improve understanding and prediction of transient climate variation, such as El Niño anomalies and to characterize and understand the effects of such variations on the terrestrial and oceanic biosphere. Reducing uncertainties in climate predictions a season or a year in advance would dramatically improve agriculture and energy utilization planning. There is increasing evidence that predictions of extreme weather events can be improved by understanding their links to interannual climate phenomena like El Niño events. Special attention is being given to measuring and modeling the effects of climate forcing factors like clouds, solar radiation, aerosols and greenhouse gases in order to improve our assessments of climate trends on time scales of decades to centuries. There is also appreciable effort going into identifying those processes that couple the biosphere and climate. A continuing priority is to understand the causes and consequences of changes in atmospheric ozone and the feedback processes between atmospheric chemical and climate change. Emphasis is also placed on the changing composition of the lower atmosphere, which is sensitive to the unprecedented increase of pollutant emissions in rapidly developing regions throughout the world.

EOS science consists of research aimed to assure that the EOS data can be accurately validated to ground, airborne and other space-based measurements, and interdisciplinary investigations oriented towards improving understanding of how the Earth works as a system involving multiple interacting components. The former is needed to assure the quality of data produced by EOS instruments, many of which will be producing the first space-based data of their type. The latter are needed to assure creative use of multiple data types together with research models to address questions associated with the linkage between Earth system components.

The objectives of the mission science team/guest investigators are to analyze data sets from operational spacecraft that support global climate change research in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology.

The airborne science project funds operations of two ER-2s, one DC-8 aircraft, and one P-3B. The project funds operation and support of a core of remote sensing instruments and a facility for analyzing and calibrating data from those instruments. The specially modified aircraft serve as test beds for newly developed instrumentation and their algorithms prior to space flight. The instrumented aircraft provide remote sensing and *in situ* measurements for many Earth science research and analysis field campaigns in all ESE science areas throughout the world. The ER-2 aircraft, in particular, are unique in that they fly well into the stratosphere and were key in collecting *in situ* data for our understanding of ozone depletion and stratospheric transport mechanisms. One of these provided support and observations, including over flights of hurricane *Georges*, for an interagency experiment designed to improve our capability to predict hurricane landfall and intensity. The DC-8 aircraft provides a unique "flying laboratory" facility for a broad range of disciplines in atmospheric sciences. The P-3B is used mainly for lower altitude operations. Many process-oriented studies involve the use of two or more aircraft together with ground and or balloon-based instruments.

NASA is implementing an Uninhabited Aerial Vehicle (UAV) science demonstration program in order to provide an opportunity for the Earth science research and applications communities to utilize UAVs in a small number of missions over the next few years.

This demonstration program should help to provide experience in the scientific use of UAVs under a variety of operating environments and conditions such as flights of 24 hours and longer duration, higher altitudes at subsonic speeds, and flights in environments hazardous to the onboard pilot in traditional aircraft. Examples of missions that may be enabled by UAVs are those to observe diurnal changes of key atmosphere, oceanic and land surface processes, or missions to observe key Antarctic or volcanic phenomena which have been inaccessible for pilot safety reasons.

The Earth science information system project has been structured to provide a balanced system of high performance computers, mass storage systems, workstations, and appropriate network connectivity between researchers and components of the system. A major portion of the project funding supports operation of a supercomputing center (the NASA Center for Computational Sciences) at GSFC. A full range of computational services is provided to a community of approximately 1,400 users representing all disciplines of Earth and space sciences. Users of the supercomputer complex select representatives to an advisory committee who are integrally involved in strategic planning for the evolution of the complex. They provide feedback on user satisfaction with services provided and help establish priorities for service and capacity upgrades. Offsite NASA-sponsored users comprise 25% of the total. The project monitors and participates in advanced technology projects, such as the HPCC program and National Science Foundation's gigabit test bed programs. Project elements at GSFC and JPL are focused on providing early access to emerging technologies for the Earth and space science communities. The early access to new technology provides the project with the opportunity to influence vendors and system developers on issues unique to the Earth and space science researchers such as data intensive computation and algorithm development. Early access also prepares a subset of the research community to make changes in research methodology to exploit the new technologies and to champion promising technologies to their colleagues and peers.

SCHEDULE AND OUTPUTS

The scientific issues of concern to Earth science are among the most complex and policy relevant of any major scientific research program. The results of Earth science program science are critical to the development of sound U. S. and global environmental policy, necessary for long-term sustainable development. Each of the science theme areas discussed in the accomplishments and plans section describe performance targets to ensure that the goal and objectives of the Earth science program science are met. A summary schedule and outputs relating to management, business practices, and bases for comparisons applicable to the whole Earth science program are in the table below.

Research & Analysis	FY 2000 Estimate/Actual	FY 2001 Estimate	FY 2002 Estimate
Number of principal investigators	1,100/977	1,208	1,216
Number of research tasks under way	1,525/1,530	1,906	1,919
Average duration of research tasks	3 years	3 years	3 years
Number of science solicitations released	12/9*	12	12
Number proposals received	1,125/834	1,125	1,300
Number of proposals rated very good to excellent	550/pending		
Number of proposals selected	360/pending		
Time to process proposal (selection through obligation)	30 days	45 days	45 days
Number of days until funding is released	Simultaneously with award	Same	Same
Percent of R & A funding obligated:			
Current Budget Authority:	100%/92%	95%	95%
Prior Budget Authority:	100%	100%	100%
Percent of program reviewed by science peers	95%	95%	95%

* Estimate revised due to consolidation of solicitations.

ACCOMPLISHMENTS AND PROPOSED RESULTS

Research & Analysis -- EOS Science

In FY 2000, continuing into FY 2001 and FY 2002, the following are significant accomplishments in the areas of Biology and Biogeochemistry of Ecosystems and the Global Carbon Cycle, Atmospheric Chemistry, Aerosols and Solar Radiation, Global Water and Energy Cycle, Oceans and Ice in the Earth System, and Solid Earth Science.

Biology and Biogeochemistry of Ecosystems and the Global Carbon Cycle: understanding changes in terrestrial and marine ecosystems and assessing their consequences for productivity, resource management, and ecosystem health.

NASA research on the biology and biogeochemistry of ecosystems and the global carbon cycle aims to understand and predict how terrestrial and marine ecosystems and biogeochemical cycles are changing. Current emphasis is on remote sensing-oriented carbon cycle science. This research addresses ecosystems as they are affected by human activity, as they change due to their own intrinsic biological dynamics, and as they respond to climatic variations and, in turn, affect climate. Research approaches range from detailed process-level studies, to global-scale observations of productivity and carbon sources and sinks, and to mechanistic modeling of ecosystem dynamics and carbon cycling processes. Major research activities focus on: quantifying changes in the global carbon cycle, especially major fluxes and the active land, ocean, and atmospheric reservoirs; documenting changes in land cover and land use; characterizing the processes that affect the Earth's capacity for biological productivity, and understanding the role of the biosphere in Earth system function.

Accomplishments

Research in FY 2000 builds on the accomplishments of previous years towards advancing the development of models of carbon uptake by terrestrial and marine ecosystems, the creation of quantitative satellite data products, and the increase in understanding of ecosystem processes important for carbon cycling.

The Synthesis and Modeling Program (SMP) of the Joint Global Ocean Flux Study (JGOFS) has developed models along three distinct but related paths: identifying carbon sources and sinks, biogeochemical cycles, and ecosystem dynamics. The SMP has been combining data from JGOFS field programs and satellite data products into models which are then used to improve parameterizations of biogeochemical processes and for skill-testing through detailed model-data comparisons. Models now include multi-element cycling (phosphorus, silicon and iron, in addition to nitrogen) and parameterizations of planktonic community structure. There are now parameterizations for calcification and nitrogen fixation that are being tested in SMP models. Reasonable, large-scale distributions of phytoplankton species can now be reproduced in global ocean models. Ocean-atmosphere and land-ocean interactions are being included, especially the former since atmospheric deposition of iron seems to be an important driver of ocean biogeochemistry. Models are also being used to investigate interannual variability, such as the Pacific-Decadal Oscillation, and future atmospheric carbon dioxide scenarios.

SeaWiFS marked its third anniversary of uninterrupted data on ocean color, and MODIS began producing a wide array of data products on marine ecosystems. Ocean color data products were combined with other satellite data on ocean properties to learn more about the interaction of biological with physical processes such as upwelling and mixing. Ocean color data were used to show the fishing industry where to deploy fishing vessels. SeaWiFS data also was used in a comprehensive study of temporal change in the Earth's biosphere as a result of the 1998-1999 El Niño/La Niña cycle.

The Sensor Inter-comparison and Merger for Biological and Interdisciplinary Ocean Studies (SIMBIOS) project has successfully merged data sets from ocean color scanners from international collaborators to create a seamless, inter-decadal time series of ocean color. These data are being used to derive more comprehensive information about global ocean productivity that is so important to understanding the ocean's response to climate change. In FY 2000 SIMBIOS expanded its international reach, and is now the definitive program for calibration/validation, merger, and inter-comparison of different ocean color sensors.

Near-daily global measurements of the terrestrial biosphere were collected by the Terra MODIS instrument, starting in February 2000. Overlap with the NOAA Advanced Very High Resolution Radiometer (AVHRR) sensor, to establish continuity of the data from the AVHRR to that from MODIS, was achieved, and research to establish quantitative relationships between AVHRR and MODIS data products is nearing completion. The MODIS global Level 0 data, as well as the Level 1A and 1B data (processed, calibrated data), are being archived at the Goddard Space Flight Center (GSFC) Distributed Active Archive Data Center (DAAC). In 2000, a rigorous program of research was conducted to calibrate and validate Terra's biospheric data and data products. Activities included refinement of algorithms and uncertainty estimates based on near-direct comparisons with correlative data such as simultaneous aircraft observations and *in situ* measurements of targets on the Earth's surface and in the atmosphere that have known, stable, or well-measured physical properties. Major field campaigns were conducted, such as Southern African Regional Science Initiative-2000 (SAFARI-2000), and smaller calibration and validation studies to check primary productivity data products.

Preliminary results from the on-going Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA) study are yielding new insights into the complexity of carbon cycling in Amazonia, with important implications for global carbon budgets and how processes are captured in biogeochemical cycling models.

Synthesis of results from the Boreal Ecosystem-Atmosphere Study (BOREAS) and several other major research programs in North American boreal and arctic ecosystems described the strong role that high-latitude ecosystems play in the climate system. Average temperature and precipitation have increased in the region, but changes in soil moisture are uncertain. Disturbance has increased; in particular, there has been a doubling of the area burned in the past 20 years. There are wide discrepancies among estimates of the size and direction of carbon dioxide fluxes between high-latitude ecosystems and the atmosphere that have not yet been resolved, but appear to relate more strongly to the analytical model chosen than the underlying data. This has set the stage for simple tests to reconcile or resolve the differences and, as a direct result, reduce major uncertainties in estimation of regional carbon dioxide fluxes and the Northern Hemisphere carbon sink.

NASA contributed to the First National Assessment of the Potential Consequences of Climate Variability and Change by providing satellite data and modeling analyses. This contribution included production of climate and ecosystem change/response scenario information and support of research for several U. S. and regional studies. The information provided for the National Assessment, as well as the results of the assessment, will be used to improve predictive models of land cover change and its impacts on natural resources and environmental quality within the U.S.

NASA participated in the SAFARI-2000 field campaign in southern Africa. This study is quantifying the effects of climate variability and management practices on the environment, as well as providing significant information on the transfer of carbon between the atmosphere and the vegetated land surface. NASA conducted a major airborne campaign in fall, 2000 that flew *in situ* and remote sensing instruments over southern Africa to measure many physical, radiative, chemical and biological properties of the land surface and atmosphere. Scientists and policy-makers plan to use the data from the SAFARI 2000 campaign to quantify the annual carbon emissions from southern Africa. SAFARI-2000 data are also being used extensively to validate EOS Terra data and data products.

Plans

NASA will continue to explore the dynamics of the global carbon cycle by developing, analyzing, and documenting multi-year data sets. In addition, new remote sensing oriented carbon cycle research will be initiated to: (1) identify, characterize and quantify global and regional sources and sinks for carbon, (2) develop, improve, and evaluate carbon cycle models, (3) use estimates of global and regional primary productivity to better understand carbon dynamics, and (4) develop new techniques, algorithms, and/or analytical approaches for deriving carbon cycle information.

The SIMBIOS project will continue to merge MODIS ocean color data into the global ocean color time series that began with Ocean Color Temperature Sensor (OCTS) and SeaWiFS. Also, the contemporaneous MODIS and SeaWiFS data will provide much improved temporal and spatial coverage of the ocean for productivity studies. This multiyear global time series will be analyzed to derive phytoplankton biomass and primary productivity for assessing interannual variability in marine ecosystems on regional scales and daily to interannual time scales. It also will be used to help understand and predict the response of marine ecosystems to climate change. ESE will continue the ocean color time series with 60% global coverage every four days. This will allow continued monitoring of global ocean productivity and identification and quantification of the ocean carbon sink(s). Data from EOS Aqua's MODIS should become available in FY 2001/2002 to add to the temporal coverage. Data from Terra and Aqua also will be used to estimate the efficiency of the carbon uptake by phytoplankton and demonstrate the value of such measurements in assessing carbon and nitrogen cycling in the open ocean.

NASA will continue the development of global land cover/use change and other data products based on Landsat and MODIS data, and provide these, along with new land cover and ocean productivity data from SeaWiFS, as preliminary products and analyses for the Millennium Ecosystem Assessment.   The development and production of a global Landsat land cover product for 1999-2000 will be initiated. First results from the Global Observations of Forest Cover (GOFC) project of the Committee on Earth Observing Satellites (CEOS) will be produced based on Landsat-7 data.

NASA will continue collecting near-daily global measurements of the terrestrial biosphere from instruments on EOS Terra and Aqua starting in 2002, and will release the first science quality, derived data products from MODIS for terrestrial and marine primary productivity. These data will be used to assess agricultural and forest productivity and forecast regional food shortages and certain disease and pest outbreaks. They also will help in estimating terrestrial biosphere carbon exchanges with the atmosphere and in developing global and regional carbon budgets.

New research investigations will be solicited for the LBA field campaign's ecological component to continue critical observations, address any gaps and new research direction, and initiate the synthesis and integration phase for LBA research.

Atmospheric Chemistry, Aerosols and Solar Radiation: monitoring and predicting how atmospheric composition is changing in response to natural and human-induced factors and how atmospheric composition responds to and influences climate.

Atmospheric change is the result of strongly interactive chemical and physical processes. Chemistry plays an important role in determining weather and climate, while the physics and dynamics of the atmosphere influence chemical processes and composition. The goals of the atmospheric Chemistry research program are to measure and understand how atmospheric composition is changing in response to natural and anthropogenic forcings, and enable accurate prediction of future changes in ozone and surface ultraviolet radiation, climate forcing factors, and global pollution.

Accomplishments

Fulfilling its Congressional mandate for upper atmosphere and ozone research, ESE has continued to provide the research community with total column ozone, ozone vertical profile, and related data sets. ESE continues to expand understanding of the chemical processes of ozone destruction and replenishment in the stratosphere through a combination of laboratory work, field experiments, and modeling, and is increasing its study of the complex chemistry of the troposphere, the lower portion of the atmosphere in which we live. ESE employs this capability to make essential contributions to international scientific assessments of ozone by the World Meteorological Organization (WMO), as well as interim studies carried out under the auspices of other groups, such as the Stratospheric Processes and their Role in Climate (SPARC) subgroup of the World Climate Research Program. NASA's contributions in this area are to develop and operate space-, airborne-, and ground-based instruments that will map the fluctuations in ozone, aerosols and related constituent gases in the atmosphere, as well as develop models that can be used to simulate prior and future evolution of atmospheric composition. These models will provide added insight into changes in the atmosphere and potentially its influence on climate.

In FY 2000 NASA utilized an integrated program of space, aircraft, balloon, ground-based and laboratory measurements, along with global and process scale modeling activities to achieve a number of significant accomplishments toward understanding the causes of variations in ozone concentrations and its distribution in the upper and lower atmosphere. In particular, NASA implemented the SAGE Ozone Loss and Validation Experiment (SOLVE). Measurements were made during the timeframe of October 1999 - March 2000 in the Arctic and high-latitude region in winter using the NASA DC-8 and ER-2 aircraft, as well as ground-based and balloon platforms. The mission also acquired correlative data needed to validate the SAGE III satellite measurements that will be used to quantitatively assess high-latitude ozone loss.

The initial analysis and publication of the PEM-Tropics-B field experiment were completed in FY 2000. This information is providing improved knowledge of the processes by which trace gases and aerosols can be transported over long distances from source regions to otherwise less polluted regions of the atmosphere.

In FY 2000 ground-based, balloon-based, and airborne in situ and remote-sensing measurements continued to show evidence that the halogen burden in the lower stratosphere has leveled off and may be starting to decline in response to actions taken in response to the Montreal Protocol. This stratospheric peaking follows a similar occurrence observed in the troposphere several years ago. This information demonstrates consistency in our knowledge of the transport of chemicals between the troposphere and the stratosphere and of atmospheric chlorine chemistry and helps lend further credence to the models used to assess future atmospheric chemical change.

The Total Ozone Mapping Spectrometer (TOMS) continued to provide a global view of the variability of total ozone abundance, which will enable the detection of the anticipated future increase in ozone associated with reductions in the atmospheric halogen burden. The production of three new data products from TOMS data continued in FY 2000. Algorithms were improved for providing surface ultraviolet (UV), tropospheric ozone column amounts, and UV absorbing tropospheric aerosols as daily products. Progress continued in understanding the characteristics in the Solar Backscatter Ultraviolet (SBUV2) satellite measurements in order to intercompare with the overlapping TOMS data set and to gap fill the periods without TOMS data. This has resulted in the release of a new continuous 20-year ozone data set, which represents one of the primary long term records of Earth system change and is used in the evaluation of atmospheric chemistry models as well as input to climate change models.

The first year of data from the Southern Hemisphere Additional Ozonesonde (SHADOZ) network was obtained. Tropospheric ozone values obtained from TOMS data were compared with integrated tropospheric ozone values from SHADOZ to assess the accuracy of the TOMS tropospheric ozone algorithms. SHADOZ data have begun to be used to help improve knowledge of the climatology of ozone in the southern subtropics.

Satellite data from the Second Stratospheric Aerosol and Gas Experiment (SAGE II) together with ground-based lidar data have shown that the distribution of stratospheric aerosol amounts continue to be as low or lower than they have been since accurate global measurements began. In response to the launch delays for the SAGE III instrument due to problems experienced by our

Russian partner, the ESE continued its support of the operation and data processing for the DoD Polar Ozone and Aerosol Mission (POAM) satellite instrument, thereby providing high latitude data on distribution of ozone, aerosols, water vapor, and nitrogen dioxide. The POAM instrument, which uses a similar observing geometry and observational technique as SAGE III, was an integral component of the SOLVE campaign. The SAGE and POAM data will help improve our knowledge of stratospheric aerosols under these new background conditions and their contribution to atmospheric chemical change.

<u>Plans</u>

Stratospheric model development is increasingly focussed on enhanced prognostic ability for Northern hemisphere high latitude ozone loss in an atmosphere perturbed by a growing abundance of greenhouse gases. The work in model development and evaluation makes use of comprehensive analysis of data from the SOLVE coordinated field experiment, which provides detailed observations of the chemical and aerosol distributions present in the Arctic atmosphere.

Work will be done to characterize atmospheric plume flowing out of East Asia; its evolution as it transits eastward over the Pacific Ocean, and its contribution to global atmospheric chemical composition. In FY 2001, a major multi-aircraft campaign known as the Transport and Chemical Evolution over the Pacific (TRACE-P) will be conducted in East Asia to help assess the effects of outflow of trace gases and particulates into the Western Pacific Ocean. This mission will incorporate the use and analysis of satellite data and atmospheric models, and improve our understanding of the way in which changes in global atmospheric chemistry affect and are effected by changes in regional air quality.

The ESE will continue to monitor and assess the impact of the Montreal Protocol and the Framework Convention on Climate Change with globally distributed measurements of the surface level concentrations of long-lived industrially produced trace gases and other biogenically-produced gases such as methane and nitrous oxide. These observations will use the Advanced Global Atmospheric Gases Experiment (AGAGE) in situ network of gas chromatographic and gas chromatographic/mass spectrometric instruments. The focus of these observations will be to continue to document the decrease in the abundance of several industrially produced halocarbons regulated under the Montreal Protocol, observe the early decline of other compounds, and track the further increases in yet other compounds that are radiatively and/or chemically active in the atmosphere. The AGAGE network will continue to closely coordinate with related networks of NOAA and NASA's international partners around the world to assure consistency in the global observation set for these compounds.

ESE will provide improved assessment of the role of the global budget of carbon monoxide and methane (including its role in the global carbon cycle) through the development of the first global climatology of carbon monoxide and total column methane using data from the MOPITT instrument aboard the EOS-Terra satellite. Data assimilation techniques combining these MOPITT measurements with chemical transport models of the atmosphere will be used to help characterize interannual differences in global emissions. Detailed validation of the MOPITT data products based on observations made with a variety of surface- and airborne-based in situ sampling, as well as ground-based optical remote sensing instruments, should enable the development and distribution of improved data products. The data will improve our understanding of the contribution of fires and fossil fuel combustion to global pollution and to better assess our knowledge of the sources of methane and thus its potential contribution to atmospheric and chemical climate change. The analysis of integrated observations involving MOPITT and the aircraft participating in the TRACE-P mission should also provide unique insights into both the role of pollution on large scale tropospheric chemical composition and on the retrieval algorithm used by MOPITT for measurement of carbon monoxide,

ESE will provide continuity of multi-decadal total ozone concentration measurements using the existing Earth Probe TOMS satellite instrument and its successor the QuikTOMS spacecraft, planned for launch in late FY 2001, and related space and ground based total ozone measurements. The verification of the QuikTOMS data set and its integration into the longer-term data record should be completed in FY 2002. The extended data set will aid in the characterization of long-term evolution of ozone and enable assessment of anticipated ozone recovery processes, and in assessment of the adequacy of current international regulations to protect the ozone layer in a changing climate. The recent behavior of ozone as reflected in this extended ozone data record, together with that of related parameters, will be analyzed and contributed to the 2002 edition of the WMO ozone assessment.

We will continue and extend the data record from the Southern Hemisphere Additional Ozonesonde (SHADOZ) network. These measurements will contribute to the development of a climatology of the high-resolution vertical distribution of ozone in the tropics and will improve the retrievals of tropospheric ozone concentrations based on the residual products from space-based observations. In particular, the extension of the data set should provide an excellent sense of the role of interannual variability of troposheric ozone concentrations in this little measured latitude band, and should play a particular role in helping to establish the validity of tropospheric ozone products from QuikTOMS and other satellite observations (e.g., the European Space Agency's ENVISAT) as well as the tropical stratospheric ozone profiles to be obtained by SAGE III using its lunar occultation mode.

We will continue the long-term (multi-decade) record of the evolution and interannual variability in high latitude ozone, aerosol, and polar stratospheric cloud profiles through the launch of SAGE III scheduled for late 2001. In FY 2002, data from this new instrument will be combined with those from previous instruments such as SAM, SAM II, SAGE, SAGE II, and POAM. This will improve our knowledge of the role that ozone changes may play in contributing to climate change as well as the way in which ozone, aerosol and polar stratospheric cloud concentrations may respond to climate variation. The SAGE III instrument should provide the first ever space-based observation of the vertical profiles of Symmetrical Chlorine Dioxide (OCLO) and Nitrogen Trioxide (NO_3); the former is a particular marker of the halogen chemistry known to be responsible for high latitude ozone depletion.

ESE will continue to explain the dynamics of atmospheric composition by building improved models and prediction capabilities. These coupled aerosol-chemistry-climate general circulation models (including projected changes in anthropogenic emissions) will examine changes in atmospheric composition projected over the 21st century. This first-time parameterization of tropospheric aerosol chemistry will help to diagnose the climatic consequences of such emissions and the associated feedbacks on atmospheric composition. Estimates of the stratospheric contribution to tropospheric ozone will be made through chemical transport and Lagrangian transport models. The stratosphere-troposphere exchange included in these model calculations will be examined for its sensitivity to global warming. The implementation of the Global Modeling Initiative (GMI) will also continue in order to provide metrics, benchmarks, and controlled numerical experiments for model and algorithm simulations performance. This will allow the development of standards of model behavior for participation in assessment exercises.

ESE will continue laboratory studies designed to assess the atmospheric fate of new industrial chemicals by characterizing the key photochemical processes (photolysis, reaction with Hydroxyl (OH) responsible for their atmospheric breakdown. In addition, improved laboratory spectroscopic measurements of the water vapor continuum will be conducted in FY 2001 and FY 2002 in order to reduce the uncertainty in the retrievals of upper troposphere/lower stratosphere water vapor from microwave soundings. In FY 2002, the first results should begin to be obtained from several laboratory studies initiated in late FY 2001 to improve knowledge of the spectroscopy needed for accurate retrieval of data from the HIRDLS, TES, and MLS instruments to fly aboard the Aura spacecraft scheduled for launch in FY2003.

Global Water and Energy Cycle: determining the partitioning and exchange of water and energy between the atmosphere, ocean and land and the consequences to the availability of fresh water.

The principal research objective is to explore the connection between weather processes and climate change and the fast dynamical/physical processes that govern climate responses and feedbacks. Particularly significant is the transformation of water among its three physical states – vapor, liquid, and ice - in the atmosphere and at the surface of the Earth. The condensation of water in cloud and snow control both the albedo and radiation balance of the planet, and the constant renewal of fresh water resources. The development of weather systems, cloud life cycles and their role in the water and atmospheric energy cycles are approached as a single integrated problem. Another central science objective is exploring the responses of hydrologic regimes to changes in climate (precipitation, evaporation, and surface run-off) and the influence of land use practices and natural processes on surface hydrology (soil moisture, snow accumulation and soil freezing) and water resources.

Accomplishments

In FY 2000 the ESE continued to invest in observations, research, data analysis, and modeling in this area. The Tropical Rainfall Measuring Mission (TRMM), launched in 1997, completed its third year of gathering information on rainfall in the tropics where two-thirds of global precipitation falls, and about which there had been little knowledge of its distribution. This is the key to understanding Earth's hydrological cycle, one of the three major processes driving Earth's climate and the global heat balance which drives seasonal change. The data from these measurements are available through EOSDIS. Tropical rainfall estimates from TRMM have further converged (Kummerow et al., 2000) and been combined with other satellite and surface-based measurements to establish a standard for comparison with previous data sets and climatologies. The diurnal variation of precipitation over the oceans has been documented with the first two years of TRMM data and shows a distinct early morning peak. The utility of precipitation information as input into numerical weather forecasting models for improvement of weather forecasts, including hurricane forecasting, has also been shown using a combination of TRMM and other precipitation data. This information will provide a scientific basis for quantitative precipitation forecasts in tropical regions, a principal scientific objective of global climate change research and the U.S. Weather Research Program. The Goddard DAAC distributed TRMM data to 220 users during the mission lifetime up to this point.

The NASA Seasonal to Inter-annual Prediction Project (NSIPP) has implemented a baseline coupled climate prediction system, consisting of the Aries global atmospheric model coupled to the Poseidon global ocean model. Experimental forecasts are able to predict tropical Pacific Sea-Surface Temperatures (SSTs) up to six months in advance. The ocean model has been successfully initialized using Special Sensor Microwave/Imager (SSM/I) surface winds data, a combination of in situ and remotely measured SST's, and sub-surface temperature data from TOGA Atmosphere-Ocean (TAO) moorings. Assimilation of sea surface height data from Topex/Poseidon is now underway and will be used for the initialization of coupled forecast experiments. Future tests will include the use of QuikSCAT surface winds in the ocean initialization procedure. The Mosaic catchment land surface model has been developed and shown to yield improved representations of the effects of sub-grid-scale topographic variability and of soil physics in meteorological models. Knowledge of soil moisture has been shown to lend to a significant improvement in predictability of precipitation over much of the U.S. in summer. A simple three-layer snow model has been added. The snow model accounts for snow melting and refreezing, dynamic changes in snow density, snow insulating properties, and other physics relevant to the growth and ablation of the snow pack. This information will provide improved seasonal predictions of changes in weather patterns associated with the El Niño cycle, and changes in land surface hydrology. The representation of the atmospheric water cycle has been improved in the atmospheric general circulation model developed by the NSIPP; the new precipitation patterns have a more realistic climatology. The model demonstrated that the predictability of summertime precipitation over the continental U.S. is controlled less by tropical Pacific sea surface temperatures and more by the soil moisture built up over the previous season. Remotely sensed soil moisture, as will be available from AMSR on Aqua, can now be assimilated into the NSIPP land model. This information will provide improved seasonal predictions of changes in climate patterns and hydrometeorology associated with the El Nino cycle.

In FY 2000, the Land Surface Hydrology Program within the ESE conducted research on understanding complex large-scale hydrological processes, retrieval of satellite-based land hydrological properties, land-atmosphere water and energy interactions and water balance, and natural disasters including floods, focusing on several regions including i) the Global Water and Energy Experiment (GEWEX) Continental Scale International Project (GCIP) of the Mississippi River Basin and North America, ii) the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA-hydromet) and iii) the Southern Great Plains (SGP).

In GCIP, research concentrated on the interaction of land surface hydrology and atmospheric phenomena, including the role of soil moisture and vegetation dynamics. In LBA-hydromet, research was conducted on physical climate and land surface hydrology, with emphasis on the influence of land use and land cover change on the variability and predictability of hydrology and climate. In SGP, research focussed on the retrieval of soil moisture using microwave technology, and the influence of soil moisture dynamics on land-atmosphere interactions.

ESE also completed the collection of satellite data needed for the 17-year cloud climatology being developed under the International Satellite Cloud Climatology Project (ISCCP). Data will be used to improve the understanding and modeling of the role of clouds in climate. Since the representation of clouds constitutes one of the major areas of uncertainty of climate models, the ISCCP data will be crucial to evaluating the competing ideas about how to represent cloud processes in global models.

Plans

In FY 2001 ESE will continue to explore the dynamics of the global water cycle by developing, analyzing and documenting multi-year data sets. The program will help resolve the wide disparity of precipitation estimates that currently exist, thus improving our understanding of the global water cycle. The continued operation of TRMM through FY 2001 will provide a fourth year of operation, allowing studies to be carried out in FY 2002 that better reflect the role of interannual variability on tropical precipitation. TRMM will obtain accurate maps of the diurnal cycle of precipitation and, in conjunction with a 10+ year reanalysis of the Special Sensor Microwave/Imager (SSM/I) data, set a benchmark for Tropical precipitation. In preparation for a future space-based measurement of soil moisture, the airborne sciences program will use aircraft and instruments to demonstrate over a variety of landscapes the capability to measure and diagnose soil moisture. It is anticipated that this information will lead to reliable estimates of evaporation, precipitation, and the recycling of rainwater over continents. In FY 2002, analysis of TRMM data will be carried out along with that from the Convection and Moisture Experiment (CAMEX) to be conducted off the coast of Florida in late FY 2001. The analysis of CAMEX observations should also improve our understanding of the atmospheric circulation and thermodynamics associated with Atlantic hurricanes and thus contributes to the goals of the U.S. Weather Research Program.

ESE will also decrease the uncertainty in determinations of radiation forcing and feedback, and thereby increase accuracy in our knowledge of the processes that lead to heating and cooling of the Earth's surface and its atmosphere. The program will continue the analysis of global measurements of the radiative properties of clouds and aerosol particles being made by the MODIS, the Multi-Angle Imaging Spectrometer (MISR), and the Clouds and Earth's Radiant Energy System (CERES) instruments on the EOS Terra satellite.

ESE will continue to explain the dynamics of the global water cycle by building improved models and prediction capabilities. Improvements will be made to our current understanding of the large-scale effects of clouds in climate and the ability to model them will also be improved through collection and processing of satellite data needed for the multi-decadal global cloud climatology being developed under the ISCCP. A decadal Surface Radiation Budget (SRB) climatology will be completed. These studies will serve as validation of parameterizations of Earth's radiative processes in models that simulate the cycling of fresh water through Earth's atmosphere and the transfer of visible and infrared radiation in the atmosphere. This information will provide a quantitative basis for estimating the components of the radiant energy budget of the Earth, and their impact on climate.

In FY 2002 ESE will continue assembling and processing satellite data needed for the multi-decadal global cloud Climatology being developed under the International Satellite Cloud Climatology Project (ISCCP). A goal is to reduce uncertainty (3-7% in monthly mean) in the current ISCCP data set of globally observed cloud characteristics, particularly in the polar regions, by comparing it with new satellite data sets that provide new constraints on the derived quantities and with in situ ground-based and airborne measurements.

ESE will initiate development of the Cirrus Regional Study of Tropical Anvils and Layers (CRYSTAL) field study. This study will determine the upper tropospheric distribution of ice particles and water vapor and associated radiation fluxes on storms and cloud systems, and on cloud generation, regeneration and dissipation mechanisms and their representation in both regional-scale and global climate models. We will also improve the determinations of radiation forcings and feedbacks, and thereby increase accuracy in our knowledge of heating and cooling of the Earth's surface and atmosphere. The analysis of global measurements of the radiative properties of clouds and aerosol particles being made by the Terra and Aqua MODIS, MISR and CERES instruments will be continued; in FY 2002 there will be a sufficient measurement record from the CERES instruments aboard Terra and TRMM that first full benefit of the multiple observing geometries of the CERES instruments can be obtained to improve knowledge of the Earth's overall radiation budget.

The Land Surface Hydrology Program focuses on research on understanding complex hydrological processes and also on the next step of prediction of hydrological processes, using modeling, satellite observations, and analysis. Research will continue to focus on the retrieval of satellite-based land hydrological properties including new sensors such as MODIS from the Terra platform, as well as land-atmosphere water and energy interactions and the water cycle using satellite data assimilation at regional to global scales, focusing in several areas around the world including the GEWEX continental scale experiment regions. The Land Surface Hydrology

Program (LSHP) will also engage the community to determine research needs and feasibility of future hydrology missions in the areas of soil moisture, cold land processes including snow and freeze/thaw dynamics, and water level and discharge. LSHP will further support the development of a new Global Water and Energy Cycle (GWEC) initiative, and continue support of continental and global hydrological databases needed for the GEWEX International Satellite Land Surface Climatology Project (ISLSCP) and the planned Coordinated Enhanced Observing Period (CEOPS).

In FY 2002, the Land Surface Hydrology Program will continue efforts on understanding and prediction of hydrological processes using observations, modeling, and analysis. Particular focus will be placed on retrieval of satellite-based land hydrological properties using sensors aboard Terra and the anticipated Aqua platform, and ground and aircraft based microwave experiments. Research is being planned for the GEWEX Americas Prediction Project (GAPP) as the logical extension to GCIP in the areas of remote sensing science, land-atmosphere water and energy interactions and water balance modeling, and data assimilation within hydrological and atmospheric models, with focus on land memory, cold land processes, and the transferability of GCIP-derived models to other regions of the globe. LSHP is also planning for two large-scale field experiments for i) cold land processes in Spring 2002 in Colorado, pending the launch of the AMSR sensor on Aqua, and ii) soil moisture in the SGP region. LSHP will continue support of the GEWEX and GWEC initiatives not only for GCIP/GAPP, but also for other large basins of the world.

The NSIPP catchment land surface model, with its improved land surface hydrology, will be coupled to the atmospheric model. Predictability experiments will focus on mechanisms responsible for the large-scale droughts such as those that occurred in the 1930s and 1950s. The results will be analyzed and documented. Finally, in FY 2002 soil moisture and snow cover derived from AMSR data will be used with the land assimilation system to estimate the initial state for the land surface model as part of NSIPP's coupled seasonal forecasts.

Oceans and Ice in the Earth System: This research theme is principally focused on the slower processes that affect the distribution of large liquid and solid water masses on the planet, the circulation of the Earth’s oceans and the mass balance of glaciers and ice sheets. Changes in oceans and ice are strongly influenced by their interactions with the atmosphere as well as their internal processes. These include: surface winds, changes in ocean water buoyancy brought about by air-sea fluxes of radiation, heat and fresh water (precipitation minus evaporation), the formation and disappearance of sea-ice, and snow accumulation on ice surfaces, glacier and ice sheet surface melt and discharge (through runoff or calving). All of these changes have subsequent impact on the atmosphere through complex feedbacks between the systems. The research objective is to model and understand the behavior of oceans and ice on all space- and time- scales that are relevant to the dynamics of the coupled ocean-atmosphere system and sea-level rise. Relatively short period and small-scale phenomena associated with upper ocean and coastal zone variability may also be studied, recognizing that process-level knowledge is necessary for predicting the behavior of coupled climate system, for understanding oceanic biological productivity and biogeochemistry, and for many marine applications.

Accomplishments

August 2000 marked the eighth anniversary of the Topex/Poseideon on orbit achievements in measuring global sea surface topography. It remains the “gold standard” for ocean altimetric measurement and continues to supply high-quality data. These data are used operationally in El Niño/La Niña predictions for the Pacific Ocean.

QuikSCAT continues to provide high quality surface wind data over the ice-free oceans. The data were used in a significant number of marine severe weather forecasts in 2000. These data are especially useful in hurricane monitoring. It has been shown that the surface wind signature of hurricane development in the Atlantic precedes cloud motion signatures normally used to identify cyclonic development.

SeaWiFS and MODIS continue to supply ocean color data. It is increasingly realized that these data will be useful in the study of the carbon cycle. Recent analyses are beginning to differentiate different marine plantonic regimes based on distinct signature in the multi-band color data. Ocean physics models incorporating more detailed biological models have been run successfully. Resources devoted to data assimilation techniques and model development are now achieving impressive results. Global assimilation and basin (Pacific, Atlantic) state estimation for parts of the 1990s have been completed. In the summer of 2000, aircraft experiments to measure ocean salinity remotely were very successful. Technology evolution and understanding of the algorithms have advanced greatly over the last three years.

The Goddard Institute for Space Studies (GISS) climate model studies on global warming as a consequence of increase of trace gases have indicated the possible importance of stratospheric ozone processes on surface climate, and thus the need for including the upper atmosphere in climate models. Their climate model also reveals that increasing greenhouse gases amplify the "high" phase of the Arctic Oscillation, providing a plausible reason why Northern Hemisphere winter warming in recent years has been much larger over the continents than over the oceans. Additional model studies have been useful for quantifying and comparing the different natural and anthropogenic climate forcings that influence long-term climate change. A sophisticated oceanic transport model has been coupled to the GISS climate model system. The ocean turbulence model breaks new ground in that it is the first to include salinity within a consistent theoretical framework. Also it is the first turbulence parameterization model to consistently represent vertical mixing throughout the whole ocean, from the strong mixing in the upper mixed layer to the weak mixing at depth. Thus the newer models being developed have improved representation of physical processes and should be able to provide more realistic simulation of future climate change, enabling better climate change assessment. The NASA Seasonal to Interannual Prediction Project (NSIPP) has developed a coupled climate prediction system model, consisting of the NSIPP-V1 global atmospheric model coupled to the Poseidon global ocean model. Experimental forecasts based on ensembles provide a statistical measure of forecast reliability. NSIPP forecasts now contribute to the consensus forecast conducted at the International Research Institute for Climate Prediction. The scalable computer architecture at NASA/GSFC has allowed the conduct of ensembles of multidecade climate simulations. These ensembles are a unique resource for the climate community.

Significant progress was made in studies of ice-covered regions of the Earth. Through collaboration with Radarsat and the Canadian Space Agency, the areas of Antarctica north of 80 degrees South latitude were precisely mapped at an unprecedented resolution in an interferometric mode which will allow estimates of the flow rate of much of the continent. These flow rates are important for estimating the amount of ice that is discharged and the influence of the world's largest ice sheet on sea level. In the northern hemisphere, the first comprehensive estimate of the mass balance of the Greenland ice sheet and its regional character was made using airborne laser altimetry surveys and information from coastal climate stations, complemented by satellite and in situ measurements. The results show that the highest central regions of the ice sheet (above 2000m elevation) are in balance, but with spatial variability. On the other hand, the lower regions are thinning, in many places at a rate of a meter per year. Based on these observations, the overall contribution of Greenland to sea level was estimated at 0.13 mm/yr; the uncertainty in this estimate is still being refined. Trends in sea ice extent for the Antarctica have been examined revealing an increase in the spatial extent of ice cover of about 1.7% per decade. The record of Arctic sea ice extent has been extended to 20 years and is continuing to show a decreasing trend of 2.7% per decade. This longer time record increases the statistical significance of the trend over previously reported values.

Plans

The launch of the NASA-CNES Jason-1 mission in late FY 2001 will enable a factor-of-four improvement in accuracy in measuring ocean basin-scale sea-level variability versus TOPEX/Poseidon. Once verified it is planned to fly a "tandem mission" to examine ocean time and space scales inaccessible to a single altimeter. Additionally, ESE will generate the first basin-scale high-resolution estimate of the state of the Pacific Ocean as part of the international Global Ocean Data Assimilation Experiment (GODAE). This information will serve as input for seasonal weather forecasting models and should lead to improved representation of the physical coupling between the oceans and the atmosphere in climate models.

Quantitative descriptions of the impact of QuikSCAT data on weather forecasts are beginning to be debated. A better understanding of the role of models and boundary layer parameterizations in assimilation of scatterometer data is expected in FY 2002.

During FY 2001 the ESE plans to continue the development of a unified GISS climate model with improved flexibility and diagnostics and full documentation. Additional GISS model simulations will be carried out with the new and upgraded GISS Global Climate Model (GCM) for the period 1950-2050. These simulations should lead to improvement of our understanding of the role of natural and anthropogenic climate forcings on global mean climate change. Additionally, an evaluation of the new vertical mixing formulation generating vertical turbulent transports in the ocean of the coupled ocean-GISS GCM is expected to reveal better and deeper insight into the long term behavior of the ocean. Assimilation of sea surface height data from Topex/Poseidon is now underway and will be used for the initialization of coupled forecast experiments. SeaWiFS data are being used to assess the penetration scale of the solar heat flux. Future tests will include the use of QuikSCAT surface winds and MODIS/TERRA sea surface temperatures in the ocean initialization procedure.

ESE will continue to explain the dynamics of long-term climate variability by building improved models and prediction capabilities. In all these assessments, use of satellite data products is central to model validation and understanding global change. FY 2002 plans will focus on decade to century time-scale computer simulations with the coupled stratosphere-troposphere and ocean; these simulations will be used to discern the role of atmosphere, land and ocean in producing the observed climate change of the twentieth century. Simulation studies are also planned for simulating the direct and indirect influences of aerosols and black carbon on our environment and cloud processes. Based on the use of turbulent transport theory, new horizontal mixing formulations for the ocean will be developed and used. Forecast skill on the large scale can be expected to improve through the improved representation of the model's intrinsic seasonal and intra-seasonal modes. Forecast skill on the smaller (regional) scale can be expected to improve through better resolution of those scales and through improved boundary layer and cloud liquid water models.

In Antarctica, high-resolution (10 m) maps of regions in Antarctica will be produced and provide an important basis for ice sheet change detection through comparison to previous and future imagery. In Greenland, elevation-change surveys of the areas showing the most dramatic thinning will be conducted to determine if the thinning rate is constant, accelerating, or decelerating. This information will significantly improve our understanding of the ice sheet's contribution to sea level rise.

The launch of ICESat, scheduled for launch in December 2001, will mark the beginning of a campaign of extensive ice sheet elevation measurements. Over time, changes in these elevations will be used to assess the mass balance of the Greenland and Antarctic ice sheets, but the first year of data will be compared to the airborne surveys begun in 1993. This comparison will provide initial assessment of ice sheet mass balance characteristics in the intervening period.

Relationships between sea ice characteristics and atmospheric conditions will continue to be investigated, and the mechanisms for formation and disappearance of sea ice will be better assessed. Links to such phenomena as the Arctic Oscillation or the North Atlantic Oscillation will be better quantified. The Antarctic circumpolar wave (the quasi-periodic motion of sea ice around the continents will be better characterized and its relationship with the responsible forcing mechanisms will be better described.

The AMSR instrument on Aqua, planned for launch late in FY 2001, will provide twice the spatial resolution of the sensors previously used for sea ice extent, concentration, and classification, with more frequencies and polarizations. These data will be used to improve the existing sea ice time series and enhance the understanding of sea ice processes. Additional applications to ice sheets (e.g. assessing the spatial melt extent) and snow cover (e.g. depth and extent) will continue to be developed.

ESE will continue to explain the dynamics of long-term climate variability by building improved models and prediction capabilities. Observational capability will be enhanced through development and demonstration of a technique to measure and diagnose open ocean variations in salinity by 0.1 practical salinity unit (psu) from airborne platforms. Salinity is a critical factor in forcing ocean circulation.

Work will be done to improve understanding and modeling of the aerosol radiative forcing of climate and its anthropogenic component as needed for the 20-year climatology of aerosol optical thickness and particle size. This will be accomplished through the development and validation of aerosol retrieval, cloud-screening algorithms, processing of satellite data and transport model evaluations. We will demonstrate the experimental seasonal climate predictions by using next-generation super computing systems and new-coupled air-ocean-land-ice models. This demonstration will incorporate all available satellite observations (e.g., TOPEX, Jason, Seawinds, TRMM, SeaWiFS, and MODIS) of key ocean surface parameters such as wind vectors and altimetry. The accuracy of realistically forced long-term climate models will be enhanced to simulate observed global temperature research. Particular emphasis will be placed on the seasonal and spatial variability over the last 40 years to develop improved confidence in ability of models used for climate prediction. This information will provide the scientific basis for reliable assessments of potential future changes in global and regional climates.

Solid Earth Sciences (in cooperation with Natural Hazards program in Applications Program, see below): Understanding the processes which govern the structure and dynamics of Earth interior and the forces which shape the Earth's crust using the vantage point of space and airborne platforms. This understanding has and will continue to lead to improvements in society's ability to understand natural hazards.

The resources for this theme area are shared between Earth Science Program Science and the Applications programs. This programmatic split under different divisional mandates reflects the nature of the Solid Earth and Natural Hazards Programs, which have striven to make research and development efforts useful in a practical way to society.

The long-standing Earth science research program in fundamental solid Earth science explores issues such as the dynamics of the Earth's interior and crust, tectonic motions, earthquake mechanisms, volcanic eruption processes, and the evolution of landscapes. Results of this and other relevant activities are developed and applied to the assessment and mitigation of natural disasters for the practice of disaster management, working together with practitioners at the international, federal, state and local levels. Through the development of technologies designed to observe and understand the Earth, the ESE possesses an inventory of observational capabilities and techniques that can be developed and applied to understanding natural hazards, characterizing natural disasters, and monitoring conditions that may lead to such events.

Accomplishments

During 2000, as the Southern California Integrated GPS Network (SCIGN) neared completion, it recorded on a daily basis the both slow inexorable crustal deformation associated with the interaction between the Pacific and North American tectonic plates. ESE led a consortium of federal state and private institutions in the development of SCIGN that included NSF, the USGS, and the Keck Foundation. Data and solutions for site velocities and time series of site positions were made available on the internet. These measurements clearly identified discontinuities in the direction and magnitude of crustal motion across fault lines. Federal, state and local agencies and companies are using the Southern California Integrated GPS Network (SCIGN) data to study ground deformation related to earthquakes, and to continually assess the vulnerability and risk of earthquakes to the region. This information will provide a scientific basis for understanding the earthquake cycle and laying out the foundation for earthquake prediction. The Hector Mine Earthquake provided a unique glimpse of the ultimate utility of the SCIGN network and of another NASA technology- Interferometric Synthetic Aperture Radar. The SCIGN network captured the initial shock wave of the earthquake as it propagated throughout the region at frequencies well below that of seismometers- thereby extending a critical view into the physics of the earthquake mechanism. Furthermore, fortuitous availability of scarce INSAR data from the European ERS-2 satellite combined with the GPS data have provided scientists with the first highly detailed inter and post seismic deformation measurements at the millimeter level. Southern California will likely prove to be a highly productive natural laboratory to test space borne remote sensing tools for natural hazards research.

ESE has strongly supported the development of international services to provide space geodetic measurements. These measurements are essential to the maintenance of a global reference frame for nearly all long term positioning requirements from Geographic Information Systems, surveying for legal and development purposes, ocean topography such as El Niño, hydrology and topography. FY 2000 saw the first likely explanation of a mysterious wobble in the Earth's rotation known as the Chandler Wobble. Using the ESE space geodetic measurements and new advanced models of ocean and atmospheric circulation, researchers at the Jet Propulsion laboratory demonstrated that ocean pressure variations were sufficient to excite the Chandler wobble.

In FY 2000, ESE researchers participated in the production of the most accurate geomagnetic field model yet, based almost solely upon satellite magnetic data gathered by the Oersted satellite and the Danish Space Research Institute. The magnetic field models are included in electronic form in many modern navigation systems, serve as reference models for mineral exploration, and are published in map form for marine and airborne navigators. These data are also advancing our knowledge of the Earth's crust and the mysteries of the circulation deep within the earth's core that generates the magnetic field. The magnetic field has been decreasing dramatically in recent years, suggesting to some that we may be entering a period of reversal of the Earth's magnetic field observed so often in the Earth's geologic history. Advanced modeling techniques are being applied to these new data sets in an attempt to better predict the evolution and the consequences of the geodynamo.

FY 2000 saw the development of the first global differential GPS correction. The new technology will allow for global real time positioning on the surface, in the air, or in orbit to better than 20 centimeters or eight inches. This development will have significant impact on global commercial interests such as agriculture, mining, robotics, and transportation. A beta version of this correction signal is being broadcast over the U.S. by NAVCOM and we expect a global signal broadcast in the next few months. NASA has also suggested that the future improvements in the GPS incorporate aspects of this new technology thereby improving the positioning and timing accuracy of the system by over a factor of ten.

FY 2000 saw the execution of the data collection phase of the ESE-led Pacific Rim II campaign. The purpose of this mission was to deploy NASA's airborne SAR, Topographic SAR, and airborne MOIDIS/ASTER simulator instruments in and around the Pacific Rim region for ecologic, hydrologic, and geologic process studies, topographic science and technology, and radar science and technology. Twenty-two countries participated in the cooperative campaign, which collected data at 201 sites in 18 different countries.

Plans

The installation of the 250 station SCIGN GPS network will be completed in FY 2001/FY 2002. Completion of the SCIGN network will provide a near real time capability for the evaluation of crustal deformation associated with earthquakes. Ground deformation information within the SCIGN array will be available within hours of an earthquake as opposed to the months required for post seismic GPS surveys. During the next five years we will evaluate the SCIGN array and validate its ability to generate data to develop an understanding of the connection between seismic risk and crustal strain leading to earthquakes. We will continue to develop the algorithms and technology of the SCIGN network to improve its utility to both the science community and to civilian, municipal, county and state government for risk assessment and disaster management. Of primary interest is improving the speed and capability of analysis software and its products. We will strive to both develop fully integrated deformation models that include GPS, seismic, and other remote sensing data sets such as INSAR and optical data sets, and to increase the timeliness of dissemination of the raw data and the model outputs for use by disaster management authorities. This will require working with data users to improve their communications infrastructure for the network. ESE will support the EarthScope initiative as a partner with the USGS and the National Science Foundation (NSF) in the development of the Plate Boundary Observatory (PBO) which constitutes a five fold increase in the number of GPS monuments in the western U.S. and Alaska. ESE's role in PBO will be to support the maintenance of the vital reference frame and GPS orbit information as well as algorithm and instrument development.

Research will continue with the development of algorithms for the GRACE Mission to better understand variations in the Earth's gravity field related to partitioning of water and atmosphere between the ice caps, ocean, and land areas. In addition ESE will continue the development of the next generation laser ranging system (SLR2000) in anticipation of its deployment in FY 2006. Based on the current budget profile ESE can not maintain the legacy system and develop SLR 2000. ESE is currently seeking partnerships that will allow for continued operation of the legacy system during development of SLR2000. SLR2000 development remains the highest priority because it will improve tracking efficiency at a lower operations cost when fully deployed. The SLR2000 system will improve the determination of the global geodetic reference frame for a host of scientific, military, and civilian applications.

ESE will conduct analyses of the near-global SRTM 30-meter topographic data for global geologic and geomorphic process studies. The SRTM will provide the first continuous digital elevation model of 80% of the Earth's surface for better understanding the composition and processes on the Earth's surface for scientific understanding. Reduction of the global data set will continue throughout FY 2002.

In FY 2001 ESE will complete the installation of the Mark IV correlator upgrade in the Very Long Baseline Interferometry (VLBI) system which will provide a factor of three to four improvement in the processing power and sensitivity of Earth rotation estimates. During FY 2001 ESE will experiment with the utility of continuous Very Long Baseline Interferometry (VLBI) observations using the Continuous Observation of the Rotation of the Earth (CORE) concept as a means of improving our understanding of atmospheric, oceanic, and internal forces affecting Earth dynamics. In FY 2002 ESE will continue to explore the dynamics of the Earth's interior and crust by developing, analyzing, and documenting multi-year data sets. We will use the daily orbit solutions for all GPS constellation satellites as a basis for cm-level orbit determinations and mm-level ground-based GPS positioning and navigation. This will enable near-real-time assessment of ground deformation for disaster response after earthquakes, and swelling of the ground as a precursor to explosive volcanic eruptions.

FY 2001 will see the first results from a three-satellite constellation of high accuracy geomagnetic satellites (Oersted, SAC-C, and CHAMP). This will be the first ever high-resolution multi-satellite study of the geomagnetic field. These same satellites also constitute the first operational GPS remote sensing constellation to measure ionospheric, atmospheric structure and dynamics and explore the utility of GPS based bistatic radar. These satellites were supported and launched under NASA's Experiments of opportunity as international collaborations with much reduced development of operations budgets. ESE expects that many new observational strategies will emerge from this constellation in the years ahead. This constellation when joined by GRACE in early FY 2002 will constitute NASA's first non-photonic remote sensing constellation.

During FY 2002 ESE will produce the first estimate of the secular (Long Term) change of the Earth's magnetic field from continuous satellite measurements of the geomagnetic field and complete the evaluation of the Continuous Observations of the Rotation of the Earth (CORE) concept to demonstrate a nearly 300% improvement in Earth rotation precision using the new Mark IV correlator technology and an international consortium of VLBI observatories.

Also in FY 2002 ESE will complete SLR2000 prototype development and begin evaluation of the performance of new SLR2000 automated satellite ranging station, evaluate the ability of the real-time precision GPS positioning software to produce better than 40 cm global real-time positioning using NASA's Global GPS Network and complete preliminary algorithms for mass flux estimation from temporal gravity field observations in preparation for the GRACE mission.

EOS Science

In 1988, NASA issued an Announcement of Opportunity (AO) for the selection of instruments, science teams and interdisciplinary investigations in support of the Earth Observing System (EOS). The initial EOS/IDS investigations were selected in 1990 to conduct basic research, develop methods and models for analysis of EOS observations, develop and refine models of Earth system processes, and forge new alliances among scientific disciplines fostering a new perspective into how the Earth functions as an integrated system. These investigations involved analysis of data from missions such as Topex/Poseidon, UARS, international instruments (e.g. ADEOS, ERS, Radarsat) and in situ observations, with results being made available through EOSDIS to enhance broad participation by the science community at large. Subsequently, additional IDS investigations were selected bringing the total to 60. EOS science teams will be recompeted during FY 2001 for selection in early FY 2002.

Mission Science Teams and Guest Investigators

The mission science team/guest investigators program provide the opportunity for scientists from all institutions to participate in the analysis, verification, and utilization of data from NASA's currently operating space-based instruments. Funding provides for analyzing data from the UARS, TOPEX, Earth Radiation Budget Satellite (ERBS) and other space borne instruments such as Solar Backscatter Ultraviolet (SBUV/2), TOMS, QuikSCAT, and TRMM. The exploitation of UARS data still involves more than 100 investigators from the United States and many other countries, notably Canada, the United Kingdom, and France. Key TOMS and SBUV/2 participants include NOAA, Russia, and Japan. Key ERBS users include a diverse set of institutions including NOAA (NOAA manifested Earth Radiation Budget Experiment (ERBE) sensors on NOAA-9 and -10 in the 1980's), GSFC, LaRC, the State University of New York, Oregon State University, and the Scripps Institution of Oceanography. The TOPEX users include France (shared in development of the mission), Japan, Australia, the United Kingdom, the Netherlands, Germany, Norway, and South Africa as well as JPL, GSFC, Columbia University, the University of Hawaii, the University of Texas, the University of Colorado, Oregon State University, Ohio State University, and the Massachusetts Institute of Technology. SeaStar/SeaWiFS principal users include GSFC, the European community, Japan, Canada, and Australia and universities in Florida, Washington, California, Texas, Maryland, and Rhode Island. At present, the largest demand for ocean color data arises from the Joint Global Ocean Flux Study (JGOFS), an international program under the auspices of the Scientific Committee for Oceanographic Research (SCOR) and the International Geosphere-Biosphere Program (IGBP). Active international participation through the International Ocean Color Coordinating Group is carried out to help synthesize data from the various space-based ocean color sensors of different nations that are currently operating. NSCAT investigators include scientists from JPL, NOAA, and Japan (manifested the NSCAT for flight on their ADEOS-1 spacecraft), and universities in New York, Washington, Oregon, and Florida. TRMM is a joint mission with Japan to measure tropical precipitation from a low inclination orbit. Participants in the analysis of Shuttle Imaging Radar/X-Band Synthetic Aperture Radar (SIR-C/X-SAR) data, in addition to JPL, represent nations in almost every continent including Italy, Saudi Arabia, China, Australia, France, Canada, Brazil, the United Kingdom, and Germany.

In a number of cases, data from one instrument have been shown to have use in other applications, and the mission analysis programs actively encourage such uses. Mission science teams are typically competed triennially. The budget for these teams increased in FY 2001, as funds that were provided to the EOS instrument science teams for algorithm development are being converted to mission analysis following the launch of the relevant missions and spacecraft.

Airborne Science and Applications

In FY 2000, seven major deployments were flown on the core NASA Earth science fleet, for approximately 1230 flight hours. The campaigns produced science data for atmospheric chemistry, land-cover/land-use, clouds research, fire and biomass burning research, and geological applications. Additional deployments with interagency aircraft provided science data for soil moisture, sea salinity, and arctic ice. Almost all planned activities were achieved despite a difficult year due to unplanned extended maintenance needed for both heavy-lift aircraft. Interagency and commercial aircraft provided substitute platforms for those research activities that could not be delayed.

For FY 2001, four major campaigns are planned for arctic ice, tropospheric chemistry, and atmospheric dynamics and hurricane research. EOS Terra and NMP EO-1 validation activities will continue. In FY 2002, six major campaigns are planned in support of EOS Aqua validation/precipitation research, arctic ice, terrestrial ecology in Amazonia, Great Lakes ice research, and tropical convection research. In FY 2002, the core ESE fleet is fully subscribed; therefore we will continue to pursue acquisition of flight hours on other cooperative or commercial aircraft to fulfill requirements that cannot be met by the core fleet.

Uninhabited Aerial Vehicles (UAVs)

The UAV science project is exploring alternative air platforms for the Earth science airborne project. Initially it will make i*n situ* and remote-sensing measurements focused on atmospheric sciences. These UAVs will stay over a target for extended periods to measure detailed temporal changes, provide unique views of cloud structures and provide calibration and verification of Earth science satellite instrumentation. In FY 2000, the UAV-based Science Demonstration Program was initiated via a NASA Research Announcement (NRA) that elicited 46 proposals in all areas of Earth science and applications. Eleven proposals were selected for additional study into the implementation of UAV missions. Implementation study results are due in 2001, and will be used to develop a business model in FY 2002 for future UAV acquisition decision-making. Two to three projects will be selected for full implementation from these eleven in FY 2001. The projects will be initiated in 2001, and are expected to fly in beginning in 2002, demonstrating the unique value added to Earth science and applications research by the UAV platform. The UAV Science program is also cooperating with the UAV flight development program to develop a scientifically credible mission profile to demonstrate the new Environmental Research Aircraft Sensor Technology (ERAST) long-endurance, high-altitude platform, which is also expected to fly in 2002.

Information Systems

The Earth science information systems project will continue to provide a balanced computational environment for NASA science researchers primarily through the facilities housed at GSFC and JPL. Partnerships with industry and other federal agencies will be used to assure the presence of the project's requirements in the strategic planning of new computational technologies. Recently-initiated cooperative agreements will allow the development of supercomputer applications up to 10 times faster than today, providing the computational studies necessary to mesh with NASA's observational and theoretical projects.

BASIS OF FY 2002 FUNDING REQUIREMENT

APPLICATIONS, EDUCATION AND OUTREACH

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Research and Analysis – Applications	33,300	42,007	
Commercial Remote Sensing	35,900	51,020	
Education	15,200	21,054	
EOS Fellowships and New Investigators.................	4,800	6,985	
Education and outreach.......................................	5,400	9,080	
GLOBE	5,000	4,989	
Subtotal Without Education Agency Investment......	84,400	114,081	
Education Agency Investment	[7,300]	[10,278]	
Total..	[91,700]	[124,359]	
Research and Analysis – Applications			45,700
Program Planning and Analysis			5,600
Applications Research			17,500
Applications Development			22,600
Education			16,500
Informal Education			1,000
Formal Education			14,500
K-16 program			2,100
Graduate Fellowships and New Investigators			7,400
GLOBE			5,000
Professional Education/Development			1,000
Outreach			1,000
Total			63,200

Note: The Education Agency Investment is reported in the Agency Education account in FY 2002.

PROGRAM GOALS

The goal for the Applications, Education and Outreach program is to expand and accelerate the realization of economic and societal benefits from Earth science, information and technology. This will be done by enabling productive use of Earth system science results, data and technology in the public and private sectors, implementing educational materials and programs to stimulate interest in Earth science through Education programs, and increasing public understanding of and involvement in Earth system science through outreach activities.

STRATEGY FOR ACHIEVING GOALS

Starting in FY 2002, the Headquarters Applications Program is restructured to consist of three major programmatic elements: Applications, Education, and Outreach. The SSC's Commercial Remote Sensing Program (CRSP) role was enhanced and expanded to become the ESE Lead Center for Remote Sensing Applications. As part of this new role, the CRSP has become the GeoSpace Applications and Development Directorate (GADD). The GADD will lead the Applications Research and Applications Development initiatives. The past CRSP activities and future activities of the Lead Center will be fully integrated into the new Applications programmatic elements. The restructuring of the Applications program involves a transition to a strategy of implementing high impact applications projects whereby we will:

- Conduct formal analysis and planning to determine when and where to make a NASA investment for maximum benefit.
- Partner with other federal agencies on projects of mutual interest.
- Collaborate more closely with industry to ensure that their investment in new products and services is used to NASA's advantage.

Applications elements include: 1) Program Planning and Analysis (PP&A), 2) Applications Research, and 3) Applications Development. PP&A will determine how priority issues that face public and private sector decision-makers can be addressed with the science and technology of ESE. Applications Research will focus on discovery and testing NASA-derived science and technology results and capabilities that may potentially impact issues of national and global significance. Applications Development involves field testing science and technology results in a realistic setting in order to determine their fitness for a target application, and creating prototypical applications in an operational setting. Applications validation is part of Applications Development, and involves the systematic and documented technical measurement, test, or evaluation of ESE and external (public agency or private) technologies, data, models with the objective of validating these against standards, user defined requirement, processes and best practices.

Applications research includes Natural Hazards research (in cooperation with Solid Earth Science program of the Research Program). This involves understanding the processes that lead to natural hazards, and will continue to provide improvements in society's ability to be more proactive in its approach to disaster management by preparing for and mitigating against the costly affects of natural disasters. The long-standing Earth science research program explores issues such as the dynamics of the atmosphere and weather systems, the dynamics of the Earth's interior and crust including earthquake mechanisms, volcanic eruption processes, and the evolution of landscapes. Results of this and other research are developed and applied to the assessment and mitigation of natural disasters for the practice of disaster management, working together with practitioners at the international, federal, state and local levels. The aim is to allow a more proactive approach to disaster management, focusing on sustainable mitigation and preparedness versus focusing on response and recovery activities.

The Education programmatic element will include 1) Informal Education, 2) Formal Education, and 3) Professional Development. Informal Education seeks to increase public awareness and understanding of how the Earth functions as a system and NASA's role in enabling development of that knowledge. Formal Education (including GLOBE) enables the use of Earth science information and results in teaching and learning at all levels of education. It also includes continued training of interdisciplinary scientists at the graduate and early-career levels to support the study of the Earth as a system. Professional Development aims to build capacity for productive use of Earth science results, technology, and information in resolving everyday practical problems.

Outreach seeks to increase awareness of the potential for applying ESE science and technology to non-science community problems and issues, and providing information to decision makers and other NASA stakeholders on applications results, status of projects and derived benefits.

SCHEDULE AND OUTPUTS

The Applications Research effort is essential to the discovery of new concepts and to the design of future missions. The primary mode of research coordination occurs through the USGCRP, the Committee on the Environment and Natural Resources (CENR) Subcommittee on Global Change Research, and the various boards and committees at the National Academies of Sciences. The applications research consists of one of the five management areas: the Natural Hazards portion of Solid Earth and Natural hazards. A summary schedule and outputs relating to management, business practices, and bases for comparisons applicable to this theme area is shown in the table below.

Natural hazards only	FY 2000 estimate/ actual	FY 2001	FY 2002 Estimate
Number of principal investigators	15/70*	65	90
Number of research tasks under way	16/75*	70	80
Average duration of research tasks	3 years	3 years	3 years
Number of science solicitations released	.5/1	1	1
Number proposals received	60/90	90	150
Number of proposals rated very good to excellent	20/30	30	50
Number of proposals selected	15/20	20	30
Time to process proposal (selection through obligation)	30 days/45 days	45 days	45 days
Number of days until funding is released	Same	Same	Same
Percent of R & A funding obligated:			
Current Budget Authority:	100%	100%	100%
Prior Budget Authority:	100%	100%	100%
Percent of program reviewed by science peers	95%	95%	95%

* These are substantially higher than last year due to misinterpreting how separate tasks were accounted for. Individual tasks for separate PIs were bundled under several summary labels and consequently were not counted individually.

ACCOMPLISHMENTS AND PROPOSED RESULTS

In FY 2000, continuing into FY 2001, the following are significant accomplishments in the area of Natural Hazards and applications research.

Accomplishments

Natural Hazards

In February 2000, the Shuttle Radar Topography Mission (SRTM) instrument aboard the Shuttle Endeavor recorded the data required to produce the first moderate-resolution digital elevation topographic map of the world. In addition, the ground data processing system was completed and the orbit/avionics information were processed. These two accomplishments were precursor activities that will allow the full production processing to begin. The data from the SRTM is allowing scientists in federal, state and local agencies, and academia to study the terrain for the purposes of basic research and also provides a multi-disciplinary applications tool for urban and infrastructure planning, resource management, environmental assessments, and disaster management including risk/vulnerability and consequence assessment.

During 2000, as the Southern California Integrated GPS Network (SCIGN) neared completion, it recorded on a daily basis the crustal deformation associated with the interaction between the Pacific and North American tectonic plates. Federal, state and local agencies and companies are using the SCIGN data to study ground deformation related to earthquakes, and to continually improve the assessment of the vulnerability and risk of earthquakes to the region. Information from the SCIGN array is providing the scientific basis for understanding the earthquake cycle and will lay out the foundation for earthquake prediction in the future. In addition, local agencies and surveying groups use SCIGN data for their spatial reference system that forms the basis for Geographic Information Systems applications. ESE, Berkley Seismological Laboratory, USGS, and local universities, used Interferometric Synthetic Aperture Radar (SAR) and GPS arrays data to conduct studies along the Hayward Fault in the San Francisco Bay region. The results of these studies found that the northern segment of the fault is not accumulating elastic strain as believed previously and therefore has a lower risk of an earthquake than previously estimated.

The first global differential GPS correction led by ESE was developed in FY 2000. The new technology will allow for global real time positioning on the surface, in the air, or in orbit to better than 20 centimeters or eight inches, and will have significant implications or global commercial interests such as agriculture, mining, robotics, and transportation. ESE expects the first commercial roll out during FY 2001.

The data collection phase of the ESE-led Pacific Rim II campaign was executed in FY 2000. The purpose of this mission was to deploy NASA's airborne SAR, Topographic SAR, and airborne MOIDIS/ASTER simulator instruments in and around the Pacific Rim region for scientific studies in ecology, hydrology, and geology, as well as environmental applications, geological hazards assessments, coastal hazards assessments, topographic science and technology, and radar science and technology. Twenty-two countries participated in the cooperative campaign, which collected data at 201 sites in 18 different countries.

ESE developed a new volcano eruption detection procedure using EOS Terra data sets that automatically detects eruptions and monitors and track plumes. These procedures will be infused into ongoing efforts with the Federal Aviation Administration (FAA) for use in aircraft routing and warning systems, and will help promote safe air travel. Cooperative programs with USGS and other international organizations on the deployment of volcano monitoring systems continued. These systems are being tested and validated by operational agencies in a number of locations including Hawaii, Mexico, Italy, the Caribbean, and the Philippines.

Through the Flood Insurance Rate Mapping program, ESE studied flooding and floodplain processes, how to process and distribute imagery of current flooding, and assessed the accuracy of new data collection techniques. These studies and assessments were aimed at the broad use of this information in flood damage assessment and for floodplain map development. ESE completed the first phase of the cooperative program with Federal Emergency Management Administration, the Army Corps of Engineers, and commercial data collection firms, to evaluate and demonstrate the utility of remote sensing data for improved, faster and less costly flood plain mapping, which resulted in the publication Light Detection and Ranging (LIDAR) and Interferometric Synthetic Radar Aperture (IfSAR) performance specifications for floodplain mapping. The follow-on phase of this activity also began with the implementation of the results of the earlier activities. Examples include the cooperative NASA/FEMA/Corps or Engineers provision of technical guidance/assistance and quality checking/validation activities associated with state-funded and operational mapping programs in North Carolina, Alaska, and Utah, using the published performance standards.

Plans for Natural Hazards for FY 2002 are described in the Applications Research Section below.

<u>Applications Research (old structure)</u>

The goal of the Earth Science Applications Research Program (ESARP) is to demonstrate the productive use of ESE science and technology in the public and private sectors in response to user needs. To achieve the goal, the ESARP works with non-NASA public and private partners to demonstrate Earth Science results, data and technology to a broad range of users for near-term practical applications.

In FY 2000, the seven Regional Earth Science Applications Centers (RESACs) applied remote sensing and related technologies to problems of regional significance and conducted region specific assessments. The RESACs were advised of the Applications Program new priority to establish operational applications that exploit ESE data, science and technology, and to consider development of such applications as part of the RESAC objectives. The RESACs responded by implementing plans for a special session on RESAC research and applications at the annual meeting of the American Society of Photogrammetry and Remote Sensing in 2001. The outcome of the RESACs will be an enhanced knowledge of potential regional consequences of climate change and variability by regional stakeholders such as state and local governments and private industry that will lead to practical advances in the management of regional resources.

Projects, funded jointly by ESE and the U.S. Department of Agriculture (USDA), developed and demonstrated applications in vegetation mapping and monitoring, environmental risk and damage assessment, resource management and precision agriculture.

Three ESE/USDA pilot projects in Arizona, Mississippi and Utah leveraged existing Land Grant and Space Grant networks into a cooperative NASA ESE-Space Grant/USDA Cooperative Extension Service Strategic Alliance in Geospatial Information Technology (i.e., remote sensing, Geographic Information System (GIS). These activities extended ESE's science results and pushed the existing applications science envelope forward in partnership with USDA. The Alliance uses remote sensing, GIS, GPS and other geospatial technologies to improve the benefits of traditional university extension activities for the Nation's farmers.

The Type 3 ESIPs (which were selected in late FY1998 as part of the EOSDIS Prototype Federation) focused on applications development and interactions with the potential broader user community; e.g., NBC Channel 4 in Washington, D.C. (weather and news) developed an integrated News and Weather Visualization System for use within NBC owned and operated television stations. The New Mexico Earth Data Analysis Center (EDAC) is working with state, regional, and local problems; e.g., EDAC and the New Mexico Land Office and Middle Rio Grande Council of Governments developed baseline GIS databases and remote sensing applications for land economics and regional hydrology, and have developed a multimedia image sampler to introduce the broader user community to the types of data available for operation and commercial applications

Specifications for state, local, regional and tribal government applications were complied through a series of regional workshops. Midwest and western regional workshops were held in Missouri (April 2000) and California (September 2000), the Northeast (November 2000), the Southeast (February 2001) and are scheduled for Alaska in May 2001. The workshops successfully acquired information about applications needs in the target community and communicated the plans to the community. A draft Broad Agency Announcement (BAA) for state, local and tribal government applications was completed in FY2000. The BAA will be issued in April 2001. A common land cover data product was developed in FY 2000, through cooperation with the USGS and based on Landsat 7 data. The product will be available in late-FY 2001 and builds on the North Atlantic Land Characterization(NALS) and Multi Resolution Land Characterization (MRLC) data sets compiled in the 1990's.

A memorandum of Understanding (MOU) was completed and implemented with the Western Governors' Association (WGA) to support WGA's efforts to incorporate NASA data, science and technology in applications. This will assist WGA member states in meeting mandated reporting requirements and decision support related to environmental assessment issues.

In FY 2000, the first ESE joint solicitation on Research and Applications was developed that encourages development of applications from ESE sponsored research. The joint solicitation, released in October 2000, identifies three science areas for proposals, carbon cycle, land use/land cover change, and terrestrial ecology, and provides the opportunity for the community to expand the science research to include applications. Proposals under this solicitation are being received and evaluated in FY 2001.

ESE expanded cooperative work with other agencies including Department of Transportation (DOT), the Environmental Protection Agency (EPA) and the U.S. Agency for International Development (USAID). ESE and DOT implemented a program in remote sensing applications that awarded four grants to university consortia to perform research on use of remote sensing and related technology to transportation issues including environmental management, infrastructure development, and emergency response. DOT also awarded eleven individual project grants in remote sensing applications. ESE and EPA identified issues to be addressed with ESE capabilities and are developing a program to address the issues identified in 2001. ESE and USAID and participated in conferences and workshops in the United States and Europe on the potential contribution of ESE capabilities for monitoring land cover/land use change related to carbon sequestration programs.

In FY 2001, Policy, Planning and Analysis (PP&A) activities were initiated in the Applications Research area. PP&A is responsible for shaping the direction of future Applications Programs, and defines the most pressing and priority information needs faced by resource managers in user organizations and determines how these needs can be satisfied with current and anticipated science and technology results. In FY 2001, PP&A activities are focused on four major applications "theme" areas that hold the most promise for economic and societal benefits: (a) Environmental Assessment; (b) Resource Management; (c) Community Growth; and Disaster Management. Assessment Panels were established in each of these areas consisting of policy-makers and acknowledged leaders.

Applications Research (ESARP) Plans for FY 2002 are reported in the Applications Research Section below.

Commercial Remote Sensing

The goal of the Commercial Remote Sensing Program (CRSP) is to accelerate the development of a preeminent U.S. remote sensing industry and link ESE scientists with the commercial remote sensing industry to develop mutually beneficial partnerships. To achieve this goal, the CRSP implements partnership programs that demonstrate joint development of technology and applications with private companies, agencies, and educational centers. Examples are the Scientific Data Buy (SDB) and the Earth Observation Commercial Applications Program (EOCAP) Hyperspectral Initiative.

In FY 2001, CRSP's increased role in Remote Sensing Applications resulted in an organizational change at the Stennis Space Center (SSC). A new directorate GeoSpace Applications and Development Directorate (GADD) was formed.

The CRSP/GADD continues to manage over 100 partnerships including programs transferred from Headquarters to SSC as the Lead Center for Applications. These partnerships focus on extending the benefits of ESE research and technology and stimulate the commercial development of value added products and services through direct working relationships with the end users in other federal government agencies, disaster management, resource management, environmental quality and community growth. The partnerships discover user requirements in a pre competitive environment and pilot techniques and methods to establish feasibility that can lead to systemic change in the end users operations.

In FY 2000, CRSP continued to successfully implement the Science Data Purchase through the direct placement of over 200 commercial tasking requests supporting science research on all seven continents. Further support was provide to the Landsat continuity Mission and Ocean Winds working groups to assist scientists and commercial providers to understand the potential commercial opportunities in future ESE science missions.

In FY 2000 CRSP and USDA worked with the growers associations representing cotton, corn, wheat and soybeans to refine the requirements definitions, translate these requirements to remote sensing technology performance and set up validation programs for six agricultural applications.

Plans for GADD for FY 2002 are described in the Applications Research and Applications Development Section below.

<u>Education and Outreach</u>

In FY 2000 the Education program had accomplishments in all major programmatic areas. In *Cross-cutting* activities, ESE evaluated 63 Earth science learning materials in its educational product review and approved 21 for distribution by the enterprise: 8 curriculum support products, 5 informal materials and 8 resources for educational product developers.

In formal education (K-16 and GLOBE), in-service educator training workshops (1-2 week intensive), and pre-service and graduate semester long courses for educators were conducted nation-wide. New undergraduate courses were created for pre-service education students at institutions, which previously did not teach Earth System science. The Earth System Science Educators Alliance (ESSEA) was formed as a support network for educators in this area.

ESE continues its effort in training the next generation of earth scientists and engineers, contributing to a workforce of interdisciplinary scientists to address the study of Earth as a system. These scientists and engineers will use remote sensing knowledge and data in practical fields related to Earth and environmental sciences, and the effects of natural and human-induced changes on the global environment. In FY 2000, 132 graduate fellowships (including 53 new awards) and 17 early-career research grants were awarded. Beginning in FY 2001, ESE is expanding the New Investigator Program to support at least 30 early-career research grants in any given year.

In informal education, ESE Earth science results and data were increasingly popular within the broadcast community. There were 129 live interviews broadcast during “prime-time” from five live shot campaigns; 31 images were broadcast during National TV News (i.e., 6:00 PM Evening News); press releases were broadcast nationally; and broadcast media issued 260 requests for archive ESE footage. Sponsored survey of museum professionals by their colleagues and the results inform ESE of what it must do for museum professionals to utilize NASA’s Earth science content. A pilot effort was conducted to train Girl Scout council and troop leaders in aspects of Earth science. Another Girl Scout Regional Council pilot effort resulted in the creation of two badge programs in atmospheric sciences for younger and junior girls.

Plans for Education are described in the Applications – Education Section below.

Plans

<u>RESEARCH AND ANALYSIS – APPLICATIONS</u>

In FY 2002, the Headquarters Applications Program is being restructured to consist of three major programmatic elements: Applications, Education, and Outreach. Commercial Remote Sensing Plans for FY 2002 are reported in the Applications PP&A, Research and Development Section.

Applications

- **Program Planning & Analysis (PP&A)**

PP&A activities are responsible for shaping the direction of future Applications Programs. PP&A defines the most pressing and priority information needs faced by resource managers in user organizations and determines how these needs can be satisfied with current and anticipated science and technology results. They determine the readiness of the marketplace to support the newly developed applications and the ability of the user institutions to sustain the applications in operational use, and develop an Applications Investment Portfolio on an annual basis which identifies a suite of prioritized opportunities based on estimates of risk, payoff, and timelines. Assessment Panels for theme areas, Environmental Assessment, Resource Management, Community Growth, and Disaster Management, will meet twice in FY 2001 to define user needs and establish the integrated direction for future program activities.

- **Applications Research** will focus on discovery and testing NASA derived science and technology results and capabilities that may potentially impact issues of national and global significance.

Operational Application Prototypes will determine how priority issues that face public and private sector decision-makers can be addressed with the science and technology of ESE.

The Joint Research and Applications solicitation will select approximately 10-12 projects in the applications areas relating to carbon cycle, carbon sequestration, land use/land cover change, and terrestrial ecology. The Solicitation seeks to support projects that exploit ESE capabilities in development of applications that can be used operationally to model the terrestrial aspects of the carbon cycle and land cover/land use changes related to terrestrial carbon sequestration efforts. Additional Research and Applications joint solicitations in areas such as water resources, quantity and quality are planned for FY 2002.

We will select approximately 8 to 12 projects under the first release of the Broad Agency Announcement (BAA) solicitation for state, local, regional and tribal government applications. Funding permitting, the BAA will be re-issued early in FY 2002 for additional projects.

Regional applications workshops will conclude with workshops in New York (November 2000), Tennessee (February 2001) and Alaska (May 2001). Additional regional and state-specific workshops may be held in FY 2002 as determined by the response to the initial BAA solicitation.

The joint ESE/EPA workshop in FY 2001 that identified key issues for EPA that can be addressed with ESE capabilities will lead to a planning process for development of projects in FY 2002 that address EPA requirements.

The Geospatial Extension Specialist (GES) projects, in cooperation with USDA/Cooperative State Research and Extension Service (CREES) and the NASA Space Grant, will be expanded to additional states, and joint NASA and USDA funds will be sought for the projects.

The Applications Program will collaborate with the South Florida Water Management District, and other agencies in the South Florida region, on tasks related to the multi-billion dollar Everglades Restoration Project for FY 2002.

The RESACs and ESIPs will begin phasing out in FY 2002. Decisions on how, when and if to re-compete these programs will be made in FY 2001.

NASA and the National Governors Association (NGA) will complete the MOU to facilitate the transition of developed applications into state executive agencies.

Environment and Health activities include projects in vector-borne disease detection, environment and health data exchange, and Shuttle imagery.

Completion of the SCIGN network will enable a near real time capability for the evaluation of crustal deformation associated with earthquakes. ESE will enable the posting of ground deformation information within hours of an earthquake as opposed to the months required for traditional post-seismic GPS surveys. ESE will develop the algorithms and technology of the SCIGN network to improve its utility to both the science community and to civilian, municipal, county and state government for risk assessment and disaster management activities. ESE will strive to develop fully integrated deformation models that include GPS, seismic, and other remote sensing data sets such as (IfSAR) and optical data sets, and increase the timeliness of the model outputs for use by disaster management authorities.

ESE will conduct analyses of the near-global SRTM 30-meter topographic data for global geologic and geomorphic process studies. The SRTM is providing the first continuous digital elevation model of 80% of the Earth's surface for better understanding the composition and processes on the Earth's surface. This will result in increased scientific understanding, better urban and infrastructure planning, environmental assessments, aircraft flight planning for aviation safety, and better natural hazards assessment and overall disaster management. Reduction of the global data set will continue throughout FY 2001.

ESE will test an automatic volcano eruption detection procedure using EOS Terra data sets that will automatically detect eruptions and monitor and track plumes, and will infuse the resulting procedures into joint NASA and Federal Aviation Administration (FAA) aircraft routing and warning systems efforts. This information will help promote safe air travel. ESE will continue to work with USGS and other International volcano monitoring programs on the implementation of low-cost GPS arrays and the use of interferometric SAR data for the development of warning systems regions vulnerable to explosive volcanic eruptions.

ESE will continue processing and analysis of PacRim II data for hazards assessment and modeling in cooperation with operational organizations such as the Pacific Disaster Center, NOAA, and the USGS.

ESE will continue to execute other cooperative programs in Disaster Management including those with:

- FEMA for better utilization of NASA science, data and technology for proactive disaster management) in general, for floodplain mapping and for risk assessment modeling using HAZUS (Hazards US) in particular;

- DOD for the better integration of Earth observation data and development of risk and consequence models into the Pacific Disaster Center. The first set of modeling activities will be implemented in FY 2001.
- The Association of American State Geologists for better use of ESE science and data in the applied geological community in general and specifically for the execution of responsibilities in all 50 of the State Geological Survey's
- Other state/local governments (e.g., NC, AK, and Utah) for the application of new technologies for floodplain/terrain mapping and modeling.

ESE will continue global real time navigation at the decimeter level and plans to investigate and validate the utility of this technology for new space borne, airborne, ground-based technologies, and will promote commercial participation in this effort. ESE will use the daily orbit solutions for all GPS constellation satellites as a basis for cm-level orbit determinations and mm-level ground-based GPS positioning and navigation. This will enable near-real-time assessment of ground deformation for better assessment of hazards as well disaster response for earthquakes, swelling of the ground as a precursor to explosive volcanic eruptions, landslides, and monitoring ground subsidence related to the extraction of fluids in the crust (e.g., ground water and petroleum).

EOCAP Hyperspectral Initiative involves partnership programs that demonstrate joint development of remote sensing technology and applications with private companies, agencies, and educational centers. In FY 2002, we will continue focusing EOCAP joint commercial applications research to stimulate the development of new commercial products. These products will ultimately provide the basis for commercial services to continue to support the ongoing geo-spatial needs of the Agricultural and Transportation agencies and the respective markets they represent. Additional commercial sources of science data (from data buy) for global change research and applications will also be investigated for use. The science data will be made available to Earth science researchers for their investigations.

- **Applications Development** involves field testing science and technology results in a realistic setting to determine their fitness for a target application, and creating proto-typical applications in pre-competitive yet near real operational settings. The planned FY 2002 developments will include:

Agriculture (AG) 20/20

Continuation of the agricultural initiative with USDA that leads to a joint solicitation and total award of fifteen to twenty partnerships of which four to six competitively selected partnerships will be with end users representative of the cotton, corn, wheat and soybean growers. These partnerships will focus on improvements in farm management practices utilizing geospatial technologies that can lead to increases in productivity and efficiencies.

State and Local

The implementation of the State, Local and Tribal Government Initiative will begin through the competitive award or four to six cooperative application pilot projects based on knowledge gained in Regional Workshops. These projects will enable the commercial development of practical tools for these government decision-makers based on the feasibility of employing geospatial technologies that address their critical requirements.

The Regional Applications Center for the Northeast (RACNE) pilot project will investigate, develop and facilitate use of NASA and other remotely sensed data in Cayuga County, NY, and will focus on the management of the 24 county watershed area of the New York Finger Lakes.

Activity will continue with the National States Geographic Information Council (NSGIC), Western Governors Association (WGA), Aerospace States Association (ASA), National Association of Counties (NACO), Mid-America States Consortium and National Conference of State Legislatures (NCSL) to plan a set of Applications Research Program demonstrations that will be dedicated to the needs of state and local government resource manages and policy-makers. Regional workshops will be held to increase communication and expand collaboration with and among the State and Local government user communities. The workshops will demonstrate ESE data products and science results to the state and local government community for their use in practical decision-making.

- **Applications Verification and Validation: I**nvolves the systematic and documented technical measurement, test, or evaluation of ESE and external (pubic agency or private) technologies, data, models with the objective of validating these against standards, user defined requirements, processes and best practices. The planned FY 2002 validation developments will include:

Creation of a Joint ESE and American Society for Photogrammetry and Remote Sensing (ASPRS) multi-disciplinary team to develop Digital Imagery Mapping Guidelines and refinement of draft Digital Imagery Standards and digital certification techniques. This team will provide a lead role in the development of LIDAR and Thermal guidelines.

Continue systems characterization activities supporting other federal agencies (DOE Multi-Thermal Imager ground truth), commercial entities (Resource 21 data simulations and validation) and Post 2002 missions Landsat Continuity and Tropo-spheric winds missions trade studies.

Continue joint NASA, NIMA, USGS and Space Imaging IKONOS data validation for the NASA research community.

EDUCATION

In FY 2002, the Education portion of the Applications Program will be restructured. Education will include three project areas: (1) Informal Education, (2) Formal Education; and (3) Professional Development. These three areas will be integrated and coordinated via a new Cross-Cutting area which will establish education focused *themes* that unify content, topics and messages across all aspects of education (informal, formal and professional) and all efforts (flight projects, field campaigns, grants, cooperative agreements, and Center efforts.) This thematic integration and coordination will be enhanced by a partnership with the National Science Foundation digital library effort that will enable projects within the different Education elements to readily share content.

In FY 2002, ESE will continue its activities in Informal Education focused on broad public awareness and understanding of the Earth as a system, the related technologies and applied uses, and the relevance to our daily lives via broadcast media (the mode by which most Americans learn about science and technology). Activities in this area are expected to yield the same magnitude of results as in previous years, with level funding. Efforts will focus on activities to improve the awareness of ESE content within the museum community; e.g., workshops, presentations and exhibits at conferences, and the Cross-cutting partnership with NSF will focus on access and usability of content by this community. The two pilot efforts with the Girl Scouts will merge into a single effort and will focus on models for scaling-up the efforts in both dimensions—leader training and badge endorsement at the national level. Pilot efforts will begin in FY 2002 in training and awareness building within the profession of Interpretation. Interpreters staff public programs at national, state and regional parks within the U.S. and are instrumental in developing permanent and rotating exhibits within these venues. Training sessions will occur at professional conferences, as an element of the National Park Service training program for Interpreters, and in other venues as identified.

Formal education will have two sub-elements: 1) K-16, and 2) Graduate and Early Career. GLOBE will be integrated into the K-16 sub-element. In FY 2002, the K-16 sub-element will focus on systemic improvement activities marrying educator enhancement activities and development of curriculum support materials to the systemic improvement activities. Efforts will focus on filling content/concept gaps in the array of curriculum support materials, and on establishing a scalable and affordable approach to educator enhancement. GLOBE efforts will be gradually integrated into the systemic improvement activities so that the numerical goals of GLOBE migrate from a focus on schools to a focus on educators, classrooms and district-wide participation in science learning, using GLOBE as the means.

During FY 2002, NASA will continue conducting workshops to train teachers in the use of Earth Science education products, and coordinate with the education organizations to affect systemic integration of ESE content into established curricular materials and learning venues. ESE will continue its annual solicitation and selection of graduate student fellowships and support at least 30 active early career research grants in Earth science.

ESE will initiate new efforts in Professional Development, focused in two areas: 1) training of professionals currently in the workforce who are allied with a funded applied applications activities at the federal, state and local level (e.g., in-service professionals), and 2) training of undergraduates in key applied fields so that they enter the marketplace with discipline specific skills in applied remote sensing (measurement, analysis, interpretation). ESE will use existing NASA investments (e.g., in undergraduate curriculum and curriculum support materials, and equipment grants at academic institutions), and then augment these as necessary. In addition, a planning activity will be undertaken to determine the existing undergraduate and professional development programs (evening, week-end, distance learning, semester and short-courses) within U.S. academic institutions and professional societies that currently offer applied, discipline-specific remote sensing as an element of the curriculum. In-service efforts will strive to utilize these existing capabilities and to expand them to better meet the needs of the in-service professionals. In FY 2002, a blend of modalities will be used to implement in-service efforts that will include pilot efforts in: 1) the use of undergraduate and graduate fellowships; 2) augmentation of existing professional development programs for GIS and natural resource managers within the federal government; and 3) scholarships for in-service personnel and their institutions to participate in existing focused training.

OUTREACH

As part restructuring the Applications program, Outreach is established as a separate effort, and will be managed by the Headquarters Applications Program. Outreach goals are to develop formal outreach plans to deliver the necessary information to appropriate stakeholders in a systematic manner, conduct special events and E-media activities (e.g., information portals, exhibits, tours, publications, web sites), and coordinate ESE outreach activities with Public Affairs to achieve the optimum benefit for NASA and the taxpayers.

BASIS OF FY 2002 FUNDING REQUIREMENT

TECHNOLOGY INFUSION

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Technology Infusion	72,615	93,202	74,200
New Millennium Program	35,200	49,989	35,800
Advanced Information Systems Technology	12,600	15,446	9,500
Advanced Technology Initiatives	9,815	12,800	8,900
Instrument Incubator Program	15,000	14,967	20,000
High Performance Computing and Communications	21,900	21,749	21,800
Total	94,515	114,951	96,000

PROGRAM GOALS

The Earth Science Technology program develops and demonstrates technologies that will enable future missions, that will reduce the cost of future missions, and that will enable a maximum 3-year acquisition timeline for flight and ground systems. The program consists of five major areas that will lead to the successful and timely development and infusion of technologies into future programs. The New Millennium Program (NMP) validates space platform and instrument technologies required for future missions. NMP space-validated technologies are required before new technologies can be flown on science or operational missions. Advanced Technology Initiatives (ATI) focus and refine ESE technology requirements and advance key component and subsystem technologies required for the next generation of process and monitoring missions. The Instrument Incubator Program (IIP) develops new instruments and measurement techniques at the system level. Advanced Information Systems (AIS) develops advanced end-to-end mission information system technologies to capitalize on the technological advances of future missions and the increased data of future missions. The goals of the NASA High Performance Computing and Communications (HPCC) project are to accelerate the development, application and transfer of high performance computing technologies to meet the engineering and science needs of the Earth science community. The ESE HPCC investment will focus on advanced developments of particular interest in Earth and space science.

STRATEGY FOR ACHIEVING GOALS

New Millennium Program

The NMP reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future Earth science mission costs through focused technology demonstrations for Earth orbiting missions. The Office of Earth Science (OES) has joined the Office of Space Science in the NMP in order to capitalize on common work from core technology development projects and specific spacecraft and instrument studies. The program will identify and demonstrate advanced technologies that reduce cost or improve performance of all aspects of missions for the next century, (i.e., spacecraft, instruments and operations). The program objectives are to spawn “leap ahead” technology by applying the best capabilities available from several sources within the government, private industries and universities. These low-cost, tightly controlled developments, the Earth Observers (EOs), will take more risk in order to demonstrate the needed technology breakthroughs and thus reduce the risk of using that technology in future science missions. Missions will be selected based on their ability to meet the science needs of the future by innovative technology that would also decrease the cost and improve the overall performance of Earth science missions.

Advanced Information Systems

Information technology advances play a critical role in collecting, handling, and managing very large amounts of data and information in space and on the ground. The objectives of the ESE Advanced Information Systems Program are to identify, develop and (where appropriate) demonstrate advanced information system technologies which:

- Enable new Earth observation measurements and information products,
- Increase the accessibility and utility of Earth science data, and
- Reduce the risk, cost, size, and development time of OES space-based and ground-based information systems.

Advanced Technology Initiative

Investment strategies within the Advanced Technology Initiatives are structured to implement a broad spectrum of developments to enable future ESE missions -- from advanced concepts, through technology advancements up the Technology Readiness Level (TRL) ladder, to readiness for infusion into future missions. Emphasis is being placed on developing new capabilities for Earth science sensors; integrated, autonomous, self-calibrating instruments and visionary architectures for future Earth Science observing systems.

Instrument Incubator Program

The IIP is expected to reduce the cost and development time of future scientific instruments for Earth science. The instrument incubator project will aggressively pursue emerging technologies and proactively close the technology transfer gaps that exist in the instrument development process. The program takes detectors and other instrument components coming from NASA’s fundamental technology development projects and other sources, and focuses on combining them into new instrument systems that are smaller, less costly, less resource intensive, and that can be developed into flight models more quickly for future Earth science missions. This includes key follow-on instruments that will provide measurements that will support the new Earth Science Research Plan.

High Performance Computing and Communications

The NASA HPCC program consists of two discipline-related integrated projects. These projects are Earth and Space Sciences (ESS), managed by the Office of Earth Science and Learning Technologies (LT). The ESS project, led by GSFC, will work in close partnership with industry, academia and government. The project used the NASA research announcement process to select ten principal investigator teams and twenty-one NASA/NSF sponsored Grand Challenge investigations and to implement them on advanced parallel computers. The LT project focuses on providing the technology base and applications to accelerate the implementation of the national information infrastructure and to communicate and distribute science and engineering materials to the education community. The LT project uses remote internet technologies developed by NASA and other federally funded agencies to expand the application outreach of its programs to traditionally unserved communities. The Internet is used as the primary means of providing access to and distribution of science and engineering data.

SCHEDULE AND OUTPUTS

Preliminary Design Reviews - Confirms that the proposed project baseline is comprehensive (meets all project level performance requirements), systematic (all subsystem/component allocations are optimally distributed across the system), efficient (all components relate to a parent requirement), and represent acceptable risk.

Earth Observer-1
Plan: February 1997
Actual: February 1997

Earth Observer-2 — Revised schedule due to delays in initiating the selection process
Plan: June 1998
Actual: October 1998

Critical Design Reviews - Confirms that the project system, subsystem, and component designs, derived from the preliminary design, is of sufficient detail to allow for orderly hardware and software manufacturing, integration and testing, and represents acceptable risk. Successful completion of the critical design review freezes the design prior to actual development.

Earth Observer-1 — Schedule changed to accommodate a grating spectrometer, which was added to the mission
Plan: April 1997
Actual: June 1997

Instruments Delivered - Confirms that the fabrication, integration, certification, and testing of all system hardware and software conforms to their requirements and is ready for recurring operation. Throughout system development, testing procedures or, as appropriate, engineering analysis have been employed at every level of system synthesis in order to assure that the fabricated system components will meet their requirements.

Earth Observer-1 — Schedule changed to accommodate the Hyperion alternative for providing the hyperspectral capability following failure to provide wedge filter detectors
Plan: May 1999
Revised: June 1999

Earth Observer-2
Plan: August 2000

After critical design review, it was determined that the SPARCLE system cost had grown significantly. After detailed peer reviews of the technical, cost and schedule status, the project was terminated. However, the progress made on the lidar technology development is still valuable and was documented

Launch Readiness Dates - Verifies that the system elements constructed for use, and the existing support elements, such as launch site, space vehicle and booster, are ready for launch.

Earth Observer-1
Plan: April 2000
Actual: November 2000

Schedule changed to accommodate the Hyperion alternative for providing the hyperspectral capability and to complete system integration and tests EO-1 was launched successfully in November 2000.

Earth Observer-2
Plan: Deleted

Project was terminated due to cost growth.

Earth Observer-3
Plan: 2005

Project in formulation.

ACCOMPLISHMENTS AND PROPOSED RESULTS

New Millennium Program

The Earth Observer (EO-1) Advanced Land Imager (ALI) is the first mission selected under the NMP series. It was launched successfully in November 2000. The EO-1 consists of an ALI instrument, a hyperspectral instrument (called Hyperion), a spacecraft, and numerous advanced technologies as an integral part of the mission. The project is now in the mission operation phase, conducting the required technology validations.

Due to the manufacturing difficulties at the ALI detector contractor, the imaging capability of the ALI was rescoped to a grating imaging capability with limited swath coverage to preserve the overall mission schedule and cost. The decision was made in the summer of 1998 to continue the hyperspectral capability, however, through another contractor's design. An additional module called Hyperion was completed by TRW that provides the hyperspectral functionality. The EO-1 mission and the associated technologies have been performing according to plan. Technology validation workshops are being planned in March and August 2001, to discuss and disseminate the technology validation results.

The Announcement of Opportunity for the EO-3 mission was released in 1999; 4 innovative measurement concepts were selected for concept definition study in February 1999. These concepts would test breakthrough technologies for remote sensing from geostationary Earth orbits. The concept definition studies were completed in September 1999. After detailed review, a Geostationary Imaging Fourier Transform Spectrometer was selected as the EO-3 mission. The concept will test advanced technologies such as large area focal-plane array, new data readout and signal processing electronics, and passive thermal switching, which will be used for measuring temperature, water vapor, wind and chemical composition with high resolution in space and time. The EO-3 project is currently in formulation, moving towards a Preliminary Design Review in March 2001. EO-3 is being planned as a partnership with the Office of Naval Research in the Department of the Navy. This partnership will include provision of funding for spacecraft and launch for the mission as well as transferring the Geostationary Imaging Fourier Transform Spectrometer (GIFTS) operation to extended Indian Ocean observations. The details of this partnership are still being negotiated. The current plan for the launch of the mission is late 2004 to 2005.

Advanced Technology Initiative

The emphasis of the ATI program will be placed on those technologies that will reduce resource requirements for the instruments or enable new missions, science measurements or applications. Additional emphasis will be placed on new emerging technologies or on those technologies where leveraging opportunities are available. Further details on instrument technologies being developed are described below.

The first ATI instrument solicitation was a broad call that addressed all five Earth science themes in the ESE strategic plan. The NASA Research Announcement was released on September 16, 1999 and 23 awards were announced on January 14, 2000. The awards addressed a broad range of technology categories to reduce the risk, size and development costs for Earth observing instruments and enable new Earth observation measurements. Awards were made for instrument components in active and passive optical, active and passive microwave as well as advanced electronic components for future ESE instruments. A second NRA is anticipated in FY 2002 to address key component technologies to support the measurements in the recent ESE Science Plan. A brief overview of these first 23 ATI awards is given in the paragraphs below.

Advanced Information Systems

The first Advanced Information Systems Technology NRA (FY 2000) was issued on November 26, 1999 and closed on January 25, 2000. This NRA solicited both hardware and software technology proposals for on-board, space-based applications in the following five categories of information system activities:

1. On-board Satellite Data Processing and Intelligent Sensor Control
2. On-board Satellite Data Organization, Analysis and Storage
3. Data Transmission and Network Configuration
4. Intelligent Platform Control
5. Information Systems Architectures and Standards.

Of the 117 proposals submitted, 30 were selected for award from each of the five categories solicited covering a variety of topics ranging from satellite on-board processing, data collection and analysis, information transmission and wireless networks, to satellite platform control and flight operating systems. The approximate value of the awards are $26 million over a three year period and will involve government, industry and university partners in 12 states and the District of Columbia.

The near-term investment strategy for Information Systems continues the Advanced Prototyping System (APS) effort, formerly known as ESDIS Prototypes, in support of EOSDIS, the NewDISS, and other ESE ground system development technology needs. Prototyping is accomplished through the Quick Response System (QRS), and the objectives are to leverage technologies to reduce costs and enhance the use of EOS data, and to explore technologies to enable NewDISS. Technologies are currently categorized into five areas: science processing, storage management, interactive access, data server access and infrastructure, and open distributed architecture.

Instrument Incubator Program

The IIP supports the development of new instruments and measurement techniques from paper studies through laboratory development and ground or air validation. NASA received 123 proposals of which 27 have been selected and are under contract. Selected projects include three from industry, six from NASA field centers, eight from universities and ten from national laboratories. Most of these IIP projects represent efforts to reduce the cost, size, mass, and resource use of current measurement approaches. Several will enable or improve measurements that cannot be made satisfactorily today. The first set of projects have start dates ranging from December 1998 to April 1999. The projects range in length from 1 to 3 years and will end between March 2000 and February 2002.

Future Incubator solicitations will focus on specific areas of science or measurement technology, taking into account the ongoing set of IIP projects, the current science priorities as reflected in the latest ESE Science Research Plan, the current set of future mission scenarios, and existing and planned technology partnerships. Based upon these considerations, the second IIP NRA will be released in 2001. For the purpose of this announcement, the following technology areas will be the primary focus for development: (1) lasers and lidar systems; (2) passive microwave radiometers; and (3) radar systems.

Proposals for other technology developments that address high priority ESE needs and are highly innovative will be considered.

The advanced geostationary study effort has been evaluating various new imaging, sounding, and lightning mapper instrument concept designs and technologies that could be applied to using geosynchronous orbit as a cost effective vantage point for supporting Earth science research objectives as well as NOAA observational requirements. The study effort has also investigated technologies and concepts for advance geosynchronous spacecraft and associated ground data processing and distribution techniques required to support the advanced instrumentation. All activities have been closely coordinated between NASA and NOAA.

In FY 2001 and FY 2002 the technology program will continue to achieve success in timely development and infusion of technologies, thereby enabling future missions and reducing their total cost. Indicators of this performance will be to annually advance at least 25% of funded instrument technology developments one Technology Readiness Level (TRL); mature two to three technologies to the point where they can be demonstrated in space or in an operational environment; and enable new science measurement capability or significantly improve performance of an existing one. These performance indicators will be refined as the Enterprise gains experience with its technology development initiatives.

BASIS OF FY 2002 FUNDING REQUIREMENT

CONSTRUCTION OF FACILITIES

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Construction of Facilities..	1,000	--	--

For additional detail, refer to the Mission Support, Construction of Facility section.

BASIS OF FY 2002 FUNDING REQUIREMENT

MISSION OPERATIONS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Mission operations			
(Upper Atmosphere Research Satellite)	7,050	10,589	4,000
(Total Ozone Mapping Spectrometer)	3,200	6,885	6,495
(Ocean Topography Experiment (TOPEX)	9,657	6,692	6,557
(Tropical Rainfall Measuring Mission)	11,100	14,671	15,604
(Earth Science)	17,000	18,941	19,594
Total	48,007	57,778	52,250

PROGRAM GOALS

Operations, Data Retrieval and Storage (ODRS) provides the data and data products from EOS precursor missions, including the UARS, TOPEX, TOMS, NSCAT and TRMM, required to understand the total Earth system and the effects of humans on the global environment.

STRATEGY FOR ACHIEVING GOALS

This program supports the observations and data management portion of Earth science activities.

Mission Operations

The objectives of the mission operations program are to acquire, process, and archive long-term data sets and validated data products. These data sets support global climate change research in atmospheric ozone and trace chemical species, the Earth's radiation budget, aerosols, sea ice, land surface properties, and ocean circulation and biology. Funding provides for operating spacecraft such as UARS, TOPEX, ERBS, TOMS, TRMM, and processing of acquired data. Key users of UARS data include NOAA, the Naval Research Laboratory, GSFC, JPL, Canada, the United Kingdom, and a number of universities including the University of Michigan, the Georgia Institute of Technology, the University of Washington, the State University of New York, and the University of Colorado. Key TOMS proponents include NOAA, Russia (manifested a TOMS on their Meteor 3 satellite launched in 1991), Japan (manifested a TOMS on their ADEOS satellite launched in 1996). Key ERBS users are a diverse set of institutions including NOAA (manifested Earth Radiation Budget Experiment (ERBE) sensors on NOAA-9 and -10 launched in the 1980's), GSFC, LaRC, the State University of New York, Oregon State University, and the Scripps Institution of Oceanography.

Alaska Synthetic Aperture RADAR (SAR) Facility (ASF) missions include the European Space Agency Remote Sensing Satellite (ERS-1-2), the Canadian (RADARSAT) for new acquisitions, , Japanese Earth Remote Sensing Satellite (JERS-1), and RADARSAT mission for historical and archival missions. Key participants involved in the ASF include the European Space Agency, Japan NASDA, Canadian Space Agency, NASA, NASA/Goddard Space Flight Center, NASA/Wallops Flight Facility (WFF), the Jet Propulsion Laboratory (JPL, the Ohio State Byrd Polar Research Center, and University of Alaska which hosts the ASF, SAR data acquisition and usage involved countries throughout the world, including, Italy, Saudi Arabia, China, Australia, France, Canada, Brazil, the United Kingdom, and Germany.

SCHEDULE AND OUTPUTS

OPERATIONAL SPACECRAFT/INSTRUMENTS

Common to all missions:	
Archive 95% of planned data acquisition	The primary criteria for success of an operational spacecraft are to obtain 95% of the planned data acquisition.
UARS (launched September 1991) continuing operations through September 30, 2001	The spacecraft launched in September 1991 with an expected three-year mission life. It has gone well beyond the expected mission life providing data to support improvements monitoring the processes that control upper atmospheric structure and variability, the response of the upper atmosphere to natural and human-induced changes, and the role of the upper atmosphere in climate variability. The spacecraft is transitioning to real-time operations due to a second recorder failure in November 1999. 95% operational. Processing 4,000 Bytes/second. UARS mission is planned for termination effective September 30, 2001.
TOPEX/Poseidon (launched August 1992) continuing operations	The spacecraft launched in August 1992 with an expected 3-year mission life. The extended mission is now in its ninth year of mission life. 100% operational. Processing 2000 Bytes/second.
ERBS/ERBE/SAGE II (launched Oct. 1984, December 1984 and September 1986) continuing operations	The ERBS spacecraft launched in October 1984. It has gone well beyond the expected mission life. 67% operational. SAGE processing 1,600 Bytes/second. ERBE processing 200 Bytes/second.

Alaska SAR Facility Missions: ERS-1 (launched 1991) JERS-1 (launched 1992) ERS-2 (launched 1995) RADARSAT (launched 1995) ADEOS (launched 1996) ADEOS-2 (launch 2002) Antarctic Mapping Mission (2001)	The Alaska SAR Facility is a ground receiving station and data processing station, which now supports ERS-2 and RADARSAT operational missions and continues to support ERS-1, JERS-1, ERS-2, and RADARSAT historical and archival missions. The Modified Antarctic Mapping Mission is an updated campaign using images from the Canadian Radarsat Satellite which is mapping the entire Antarctic continent and its evolutionary processes. These images are available for the NASA approved Antarctic research community. All of these are international missions. There are currently no unique metrics defined for ASF other than the common metric listed above, which exceeds RGS: 99/7% operational, acquisition 9956 Bytes/Second/Day. DAAC: 95% operational production Bytes/Second/Day.
TOMS FM-3 (launched July 1996) continuing operations	The TOMS-EP spacecraft was launched in July 1996 with an expected five-year mission life. It has completed its primary mission phase. The first global ozone image was produced and released September 13, 1996. Automated processing and distribution of science products began September 20, 1996 and Internet distribution started on October 7, 1996. 100% operational. Processing 250 Bytes/second.
TRMM (Launched November 1997) continuing operations through 2004	The spacecraft launched in November 1997 with a 3-year mission life. All operations are nominal, except the CERES instrument, which is non-operational due to an anomaly with Data Acquisition Assembly Converter. 95% operational. Processing 250,000 Bytes/second.
SeaStar / SeaWiFS / Ocean Color (Launched August 1997 continuing operations for data processing)	The spacecraft launched in August 1997. This is a data buy from Orbital and the operation of the spacecraft is an Orbital responsibility. 100% operational. Processing 41,700 Bytes/second.
Landsat-7 (Launched April 1999)	Landsat-7 was launched April 15, 1999 and declared operational in July 1999. NASA agreed to operate the satellite through FY 2000. 100% operational. Processing 250 scenes/day. USGS assumed operation and funding responsibility beginning October 1, 2001.
Terra (Launched December 1999)	Terra spacecraft was launched December 18, 1999 and with checkout completed in April 2000. 100% operational. Terra is processing 200 gigabytes of data per day.

ACCOMPLISHMENTS AND PROPOSED RESULTS

Data has been acquired, processed, disseminated, and archived to meet mission requirements for user availability of timely and accurate data products for global and/or regional monitoring purposes from all operational spacecraft and instruments. The current emphasis on global modeling in support of policy decisions on such matters as the impact of deforestation, ozone depletion, and environmental quality worldwide has led to the acquisition and manipulation of unprecedented amounts of environmental data. The accompanying computational demand has led to a doubling of production computing capacity and quadrupling of mass storage capacity in the last two fiscal years.

In the mission operations project, responsibility for assigned missions is assumed approximately 120 days after launch. Data are acquired, processed, disseminated, and archived to meet mission requirements for user availability of timely and accurate data products.

User requirements will be met in 2000 and 2001 by continuing operations of on-orbit spacecraft and instruments including the UARS, TOPEX, and ERBS missions; and continuing receipt of ERS-1, JERS-1, and RADARSAT data at the Alaska SAR Facility, in addition to data for OTD, SeaStar/SeaWiFS, TOMS and TRMM.

BASIS OF FY 2002 FUNDING REQUIREMENT

INVESTMENTS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Minority University Research & Education Program (MUREP)	7,300*	8,780*	
Education..	--	1,497*	
Total..	7,300*	10,277*	

* FY 2000 and FY 2001 MUREP covered in Applications, Commercialization and Education (ACE).
* In FY 2002, this activity has been transferred to the Agency Education program.

PROGRAM GOALS

The above funding requirements represent the ESE budget contribution to the Minority University Research and Education Programs (MUREP) and the Education Program.

STRATEGY FOR ACHIEVING GOALS

The Earth Science Strategic Enterprise investments in higher education institutions include Federally mandated outreach to the Nation's Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), including Hispanic-Serving Institution and Tribal Colleges and Universities. This outreach is achieved through a comprehensive and complementary array of strategies developed in collaboration with the Office of Equal Opportunity Programs. These strategies are designed to create a broad-based, competitive aerospace research capability within Minority Institutions (MI's). This capability fosters new aerospace science and technology concepts by integrating Earth Science Enterprise-related cutting-edge science and technology concepts, practices, and teaching strategies into MI's academic, scientific and technology infrastructure. As a result, increasing the production of more competitive trained U.S. students underrepresented in NASA-related fields who, because of their research training and exposure to cutting-edge technologies, are better prepared to enter graduate programs or the workplace. Other initiatives are focused on enhancing diversity in the Earth Science Strategic Enterprise's programs and activities. This includes exposing faculty and students from HBCUs and OMUs, and students from under-served schools, with significant enrollments of minority students, to the Enterprise's research efforts and outcomes, educational programs, and activities. To support the accomplishment of the Enterprise's mission, these programs are implemented through NASA Centers and JPL. The Centers and JPL support the MUREP through use of their unique facilities, program management and grant administration, and commitment of their personnel to provide technical assistance and assist in other facets of program implementation. Extensive detail as to how this funding is utilized is located under the MUREP portion of the budget.

In carrying out its Education Program, NASA is particularly cognizant of the powerful attraction the Earth Science mission holds for students and educators. The unique character of Earth Science exploration, scientific, and technical activities has the ability to captivate the imagination and excitement of students, teachers, and faculty, and channel this into an investment which support NASA's Education Program.

In fulfilling its role to support excellence in education as set forth in the NASA Strategic Plan, the NASA Education Program brings students and educators into its missions and its research as participants and partners. NASA provides the opportunity for educators and students to experience first hand involvement with Earth Science Enterprise scientists and engineers, facilities, and research and development activities. Examples of such opportunities include the Learning Technologies Program, a new Undergraduate Internship Program, and the Graduate Student Researchers Program. The participants benefit from the opportunity to become involved in research and development endeavors, gain an understanding of the breadth of Earth Science activities, and return to the classroom with enhanced knowledge and skills to share with the entire education community. Detail as to how this funding is utilized is located under the NASA Education portion of the budget.

BASIS OF FY 2002 FUNDING REQUIREMENT

EARTH SCIENCE INSTITUTIONAL SUPPORT

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Institutional Support to Earth Science	[246,979]	[231,569]	236,978
Research and Program Management (R&PM)	[230,682]	[208,909]	220,129
Personnel and related costs	[173,528]	[166,141]	168,902
Travel	[6,080]	[5,226]	5,426
Research Operations Support (ROS)	[51,074]	[37,542]	45,801
Construction of Facilities (CoF) - (Non-Programmatic)	[16,297]	[22,660]	16,849
Earth Science Full-Time Equivalent (FTE) Workyears	[1,976]	[1,816]	1,733

PROGRAM GOALS

The two primary goals of this budget segment are to:

1. Acquire and maintain a civil service workforce, that reflect the cultural diversity of the Nation and, along with the infrastructure, is sized and skilled consistent with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the Earth Science Enterprise (ESE).

2. Ensure that the facilities critical to achieving the ESE are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

RESEARCH AND PROGRAM MANAGEMENT (R&PM): program provides the salaries, other personnel and related costs, travel and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 80% of the requested funding. Administrative and other support is approximately 18% of the requests. The remaining 2% of the request are required to fund travel necessary to manage NASA and its programs.

CONSTRUCTION OF FACILITIES (CoF): budget line item provides for discrete projects required for components of the basic infrastructure and institutional facilities and almost all are for capital repair. NASA facilities are critical for the ESE, to sustaining the future of aeronautics and advanced space transportation, which both support military and private industry users. NASA has conducted a thorough review of its facilities infrastructure, finding that the deteriorating plant condition warrants an increased repair and renovation rate to avoid safety hazards to personnel, facilities, and mission, and that some dilapidated facilities need to be replaced. Increased investment in facility revitalization is needed to maintain a facility infrastructure that is safe and capable of supporting NASA's missions.

ROLES AND MISSIONS

The detail provided here is for the support of the ESE institutions - Marshall Space Marshall Space Flight Center, Stennis Space Center, Ames Research Center, Dryden Flight Research Center, Langley Research Center, Goddard Space Flight Center, and NASA Headquarters.

MARSHALL SPACE FLIGHT CENTER (MSFC)

The ESE funds approximately 2% of MSFC's Institution cost. Through the Global Hydrology and Climate Center (GHCC), a joint venture with academia, MSFC engages in research, education, and the development of Earth science applications. The GHCC focuses on using advanced technology to observe and understand the global climate system and applies this knowledge to agriculture, urban planning, water resource management, and operational meteorology.

STENNIS SPACE CENTER (SSC)

The ESE funds approximately 17% of SSC's Institution cost. Through the Applications Program, SSC will enhance U.S. economic competitiveness via commercial partnership programs that apply remote sensing technologies in business applications and reduce new product development costs. As part of the Applied Research and Data Analysis program, SSC will conduct fundamental and applied research which increases our understanding of environmental systems sciences, with emphasis on coastal research of both land and oceans.

AMES RESEARCH CENTER (ARC)

The ESE funds approximately 5% of ARC's Institution cost. ARC builds instruments and computer models for measurement and analysis of atmospheric constituents and properties from aircraft platform are being developed. Applied research and developments to enhance the use of remote and in-situ sensing technology for Earth resources applications continues. ARC provides information systems and high end computing support for Earth Sciences knowledge acquisition.

DRYDEN FLIGHT RESEARCH CENTER (DFRC)

The ESE funds approximately 6% of DFRC's Institution cost. DFRC conducts flight operations in support of Airborne Science Missions utilizing aircraft for data collection and observation.

LANGLEY RESEARCH CENTER (LaRC)

The ESE funds approximately 13% of LaRC's Institution cost. LaRC performs an agency-designated Atmospheric Science mission role in support of the ESE in the NASA Strategic Plan. As Lead Center for Focused Atmospheric Science Missions, LaRC conducts a world-class peer reviewed and selected atmospheric science program in support of national goals in preserving the environment and in fundamental science. Specific LaRC discipline areas of expertise are Earth radiation research, particularly the role of clouds in the Earth's energy budget; middle and upper atmospheric research; and tropospheric research. LaRC performs innovative scientific research to advance the knowledge of atmospheric radioactive, chemical, and dynamic processes for understanding global change; develops innovative passive and active sensor systems concepts for atmospheric science measurements. LaRC conducts a technology development program that develops advanced laser and LIDAR technologies for Earth science missions; advanced passive remote sensing technologies; develops advanced ultra-lightweight and adaptive materials, structural systems technologies and analytical tools for significantly reducing the end-to-end cost and increasing the performance of earth observation space instruments and systems. LaRC conducts an Application, Education and Outreach program that utilizes scientific data for non-scientific applications and in support of science and math education. LaRC also serves as a Primary Data Analysis and Archival Center (DAAC) for Earth Radiation and Atmospheric Chemistry for the Earth Observing System.

GODDARD SPACE FLIGHT CENTER (GSFC)

The ESE funds approximately 34% of GSFC’s Institution cost. GSFC is the Lead Center for Earth Science, including the Earth Observing System (EOS). This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers and scientists.

GSFC manages the Earth Explorers Program and conducts science correlation measurements from balloons, sounding rockets, aircraft and ground installations. It also manages, on a reimbursable basis, the acquisition of meteorological observing spacecraft for the National Oceanic and Atmospheric Administration (NOAA).

Lead Center for the Independent Verification & Validation (IV&V) Facility in Fairmont, West Virginia. The IV&V Facility is responsible for providing independent assessments of project software and for the management of all software IV&V efforts within the Agency.

NASA HEADQUARTERS (NASA HQ)

The ESE funds approximately 11% of NASA HQ’s Institution cost. The mission of NASA HQ is to plan and provide executive direction for the implementation of U.S. space exploration, space science, Earth science, aeronautics, and technology programs. This includes corporate policy development, program formulation, resource allocations, program performance assessment, long-term institutional investments, and external advocacy for all of NASA.

At NASA HQ, the broad framework for program formulation will be conducted through ESE. Consistent with the NASA strategic plan, the ESE develops program goals and objectives to meet the needs of external customers within the policy priorities of the Administration and Congress.

The Enterprise’s Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTE’s across the agency. A more complete description can be found in the Mission Support/two Appropriation budget section.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF AEROSPACE TECHNOLOGY **AEROSPACE RESEARCH AND TECHNOLOGY PROGRAMS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Aerospace Research and Technology	985,395	1,241,658	1,357,600	SAT 4.1-1
Aerospace Institutional Support	[708,953]*	[810,359]*	871,239*	SAT 4.1-89
Commercial Programs	140,005	162,442	146,900	SAT 4.2-1
Total	1,125,400 [1,834,353]*	1,404,100 [2,214,459]*	2,375,739*	

* Funding includes direct-program Institutional Support to Aerospace Technology Enterprise (from FY 2001 President's Budget, Mission Support section)

PROGRAM GOALS

NASA is responsible for addressing aeronautics and space priorities as outlined in national aeronautics and space policies. The responsibility of industry and operational government agencies is to meet their near-term customer requirements through evolutionary advancements to their products. The Aerospace Technology Enterprise's responsibility is to provide revolutionary advancements in science and technology that sustain global U.S. leadership in civil aeronautics and space, reduce the impact of aerospace operations on the public. Also to provide the public with a safe, reliable and efficient air and space transportation systems and reduce the costs associated with space travel. This includes the development of revolutionary concepts, physics-based analytical tools and modeling, revolutionary manufacturing environments and processes, and breakthrough technologies that will enable the Nation's air and space transportation systems to routinely demonstrate capabilities tomorrow that are not envisioned today.

As we approach the centennial of flight, the technological changes that have occurred in the past century are astounding. What is even more impressive is the impact of these changes on the Nation. Aerospace technologies are essential for the National Defense and provide unprecedented mobility for the general public. Aerospace spin-off technologies have revolutionized the way we live, greatly improved the quality of life of the general public, and have become a driving force in keeping our economy strong. Aviation is vital to the Nation, but it is at a crossroads. With the National Airspace System approaching gridlock, the impediments to continued growth and prosperity have never been greater. Industry, the FAA, and NASA must work together to ensure that long-term, high-payoff research that could alleviate these conditions makes its way into the next-generation systems. The military is also becoming more reliant on commercial developments. The answer to ensuring the continued viability of aerospace technology is not through evolutionary or near-term approaches alone, but through the development of revolutionary, long-term approaches. The vision of aerospace for the 21st Century is based on promising advances in emerging technology such as nanotechnology, biotechnology, and information technology. The Office of Aerospace Technology is moving to develop the technological foundation, through investments in revolutionary, high-risk, and breakthrough technologies, to make the vision a reality.

During the past year, the Enterprise Strategic Plan has been updated, to reflect a new emphasis on innovation, as well as to reflect the technical progress and programmatic insights gained in recent years. The main goals of the Enterprise have been reformulated: Goal One is titled "Revolutionize Aviation," Goals Two is "Advance Space Transportation" Goal Three is "Pioneer Technology Innovation," and a fourth goal, added in this plan, is "Commercialize Technology," to formally recognize this important and ongoing Enterprise role.

Goal One: Revolutionize Aviation - enable the safe, environmentally friendly expansion of aviation.

Expanding the aviation system of the future to meet the demands for growth will mean providing a more distributed flexible and adaptable network of airways. This growth must take place within the physical and environmental constraints of today's system, while meeting the evolving needs of air travel. Advanced vehicles will operate in this new infrastructure, with better performance and new capabilities such as "morphing" wings that optimize their shape for take-off, flight, and landing. The aircraft of the future will be safer, cleaner, quieter, and faster. Advanced information and sensor technologies will make air travel safer and more efficient. Air transportation will be easily accessible from urban, suburban, and rural communities and affordable for all citizens.

Civil aviation provides the backbone for global transportation, the very basis of global economic and cultural exchange and integration. It is a large and growing market that the U.S. has traditionally led. Projected growth approaches a tripling of air traffic over the next twenty years. NASA coordinates its aviation technology development activities with the FAA and DoD through the *National Research and Development Plan for Aviation Safety, Security, Efficiency, and Environmental Compatibility.* Examination of various alternative futures suggests that there is also the potential for greater dispersion of operations, for a very high value for flexible, ultra-reliable operations, and for increasing utilization of aircraft with unique operational characteristics.

A need exists to address the fundamental, systemic issues for the aviation system to ensure the continued growth and development appropriate to the needs of the national and global economies. These systemic issues—safety, capacity, environmental compatibility, and mobility cut across markets including large subsonic civil transports, air cargo, commuter and general aviation. To ensure these systemic issues do not become constraints, dramatic improvements should be aggressively pursued. Therefore, the Enterprise has worked with its partners to identify five enabling technology objectives to sustain the United States aeronautics leadership by providing high-risk technology that cuts across all markets in Civil Aviation:

- Make an already safe air transportation system even safer by reducing the aircraft fatal accident rate by a factor of five by 2007 and by a factor of 10 by 2022 as compared with the baseline period of 1990 to 1996.

- Protect local air quality and our global climate by reducing Oxides of Nitrogen (NOx) emissions of future aircraft by 70 percent by 2007, and by 80 percent by 2022 (using the 1996 ICAO Standard for NOx as the baseline). Reduce carbon dioxide (CO_2) emissions of future aircraft by 25 percent and by 50 percent in the same timeframes (using 1997 subsonic aircraft technology as the baseline).

- Improve the quality of life for airport neighbors and travelers and reduce airport operations constraints by reducing the perceived noise levels of future aircraft by a factor of two (10 decibels) by 2007 and by a factor of four (20 decibels) by 2022, using 1997 subsonic aircraft technology as the baseline. The long-term 20-decibel objective for noise reduction will, in most cases, contain objectionable aircraft noise within the airport boundaries (55 Day/Night Level contour), freeing the system of most noise restraints.

- Enable the movement of more air passengers with fewer delays by doubling the aviation system throughput, in all weather conditions, by 2007 and triple it by 2022.

- Enable people to travel faster and farther, anywhere, anytime by reducing inter-city door-to-door transportation time by half by 2007 and by two-thirds by2022, and reduce long-haul transcontinental travel time by half by 2022.

Goal Two: Advance Space transportation - create a safe, affordable highway through the air and into space

The objectives of this goal are described in terms of the desired system attributes – Mission Safety, Mission Affordability, and Mission Reach (faster travel times) respectively. Technology for the next generation of space transportation is focusing on an order-of-magnitude increase in safety and reliability and an order-of-magnitude decrease in cost. NASA will focus on advances in systems, materials, structures, propulsion, and aerodynamics to increase operating margins while incorporating advanced, intelligent health management for reliability.

Revolutionizing our space transportation system to significantly reduce costs and increase reliability and safety will open the space frontier to new levels of exploration and commercial endeavor. With the creation of the Integrated Space Transportation Plan (ISTP), the Agency defined a single, integrated investment strategy for all its diverse space transportation efforts. By investing in a sustained progression of research and technology development initiatives, NASA will realize its vision for generations of reusable launch vehicles that will surmount the Earth-to-orbit challenge.

- Radically improve the safety and reliability of space launch systems by reducing the incidence of crew loss for a second generation Reusable Launch Vehicle (RLV) to 1 in 10,000 missions (a factor of 40) by 2010 and to less than 1 in 1,000,000 missions (an additional factor of 100) for a third Generation RLV by 2025.

- Create an affordable highway to space, by reducing the cost of delivering a payload to Low Earth Orbit (LEO) to $1000 per pound (a factor of 10) by 2010, and to $100 per pound (an additional factor of 10) by 2025.

Goal Three: Pioneer Technology Innovation - enable a revolution in aerospace systems.

This goal addresses the need for a revolution in engineering tools and processes, and a culture change in our organizations if we are to ensure success in Goals One and Two. To create the air and space transportation systems of the future, as well as other highly complex civil and military systems, we need to develop a new approach to engineering that puts safety, reliability and mission assurance first. Critical to unlocking this capability are high-fidelity, collaborative tools and environments with intuitive human interfaces that allow us to simulate, in virtual space, complete product life-cycle evaluations before cutting the first piece of hardware. New system or vehicle characteristics such as intelligence, rapid self-repair, and adaptability will come about through innovation and integration of leading-edge technology, most notably nanotechnology, biologically-inspired technology and intelligent systems. By focusing on how these technologies can address design issues faced by NASA missions and other customers, NASA will accelerate the introduction of new, revolutionary capabilities.

Pursuing technology fields that are in their infancy today, developing the knowledge bases necessary to design radically new aerospace systems, and performing efficient, high-confidence design and development of revolutionary vehicles are challenges that face us in innovation. These challenges are intensified by the demand for safety in our highly complex aerospace systems. The goal to Pioneer Technology Innovation is unique in that it focuses on broad, crosscutting innovations critical to a number of NASA missions and to the aerospace industry in general.

- Enable rapid, high-confidence, and cost-efficient design of revolutionary systems by demonstrating advanced, full-life-cycle design and simulation tools, processes, and virtual environments in critical NASA engineering applications by 2007 and demonstrating an integrated, high-confidence engineering environment that fully simulates advanced aerospace systems, their environments, and their missions by 2022.

- Enable fundamentally new aerospace system capabilities and missions by integrating revolutionary technologies to explore fundamentally new aerospace system capabilities and missions by 2007; and demonstrating new aerospace capabilities and new mission concepts in flight by 2022.

Goal Four: Commercialize Technology - extend the commercial application of NASA technology for economic benefit and improved quality of life

This goal is not a new requirement but by its inclusion as a goal brings greater awareness to NASA's responsibility to transfer and commercialize technology resulting from NASA's research and development.

Commercialization is an outward; external process that provides benefit to the public fully supported by a network of NASA-affiliated organizations across the U.S. NASA technology benefits the aerospace industry directly. The creative application of NASA's advanced technology to disparate design and development challenges has also made numerous contributions to other areas such as the environment, surface transportation, and medicine. NASA achieves this by partnering with both aerospace and non-aerospace industry as well as academia. These partnerships involve the full range of NASA's assets: technological expertise, new technologies, and research facilities. The NASA Commercial Technology Network (NCTN) is a key mechanism for enabling technology transfer and commercialization. This network provides unique expertise and services to U.S. enterprises, facilitating the transfer, development, and commercialization of NASA-sponsored technology.

An effective external transfer effort augments our economy, benefits the public, and fosters technology leveraging across NASA programs. NASA will continue to improve its technology commercialization and outreach programs to ensure the widest application of NASA-developed technology to benefit the Nation.

STRATEGY FOR ACHIEVING GOALS

When the Enterprise identified the four goals and their enabling objectives, it was recognized that they are highly ambitious and will stretch the boundaries of the U.S. knowledge and capabilities. These goals and objectives provide the framework for the development of a portfolio of Aerospace Research and Technology (R&T) activities in both basic and focused research and technology development. Both the Aerospace R&T Base and Aerospace Focused programs contribute to the accomplishment of the Enterprise Goals which in turn support National objectives in terms of aerospace safety, capacity, reliability, efficiency, cost, and leadership. In order to achieve these National objectives, NASA carries out its aerospace technology mission in close partnership with U.S. industry, academia and other Federal agencies, such as the Federal Aviation Administration (FAA) and Department of Defense (DoD). During FY 1998, the Enterprise developed detailed roadmaps to define the path that it would need to follow in order to allow this partnership to achieve these objectives. Although the Enterprise Goals were revised in FY 2000, the technical objectives have remained unchanged with the exception of the newly developed mobility objective. Roadmaps for the mobility will be generated during FY 2001.

The Aerospace R&T program consists of five base-research programs and seven focused programs. The base programs are responsible for the development of advanced concepts, physics-based understanding of aerospace phenomena, validated models design tools and environments, design and manufacturing aids and processes, and suites of aerospace discipline and multi-discipline technologies that are not directly orientated to a specific user, vehicle, or application. The focused programs build upon the technological foundation provided by the R&T Base and further develop and adapt basic research products, in order to satisfy specific user requirements or system applications, to the point at which they could be transferred to a user for further development and implementation.

The Enterprise Technology impact is evaluated by both its Advisory Committee and an independent Inter-Center Systems Analysis Team (ISAT). The ISAT not only assesses the synergistic effect of all the Enterprise R&T activities toward meeting the goals but also provides an assessment of the individual contributions of each R&T activity toward each goal. Based on the information provided by the ISAT team, the current R&T program was adjusted to better meet Enterprise long-term goals in a financially constrained environment.

These changes are described below:

- Restructured the Base R&T program by combining like activities in a synergistic manner that reduces management overhead, eliminates redundant and overlapping research activities, and concentrates our core expertise in critical technologies.

  - Created a new base research program entitled Computing, Information, and Communications by including the existing Aerospace Base programs in Information Technology and Aerospace Operations Systems (AOS); the existing Space Base programs in Space Communications, Thinking Systems, Autonomy and Search and Rescue; and the new activities in Aerospace Autonomous Operations, Design for Safety, and Bio-Nanocomputing and Electronics. Early infusion will be necessary for NASA to achieve the challenging goals for its many future missions of planetary and deep space exploration, science data acquisition, near-Earth orbit space operations, aeronautical systems, the National Airspace system and space transportation systems. To ensure the highest quality research and strong ties to NASA's missions, these investments will be guided by technology development agreements signed by customers in other NASA Enterprises and will be subject to external, independent reviews. A significant portion of these investments will be externally competed. To ensure the high quality research, the program will be subject to external independent reviews and a significant potion of the research will be externally competed. To endure strong ties to technology customers, a team of potential internal and external users will assess the relevance of the research to future NASA and commercial/government applications and provide recommendations for ongoing and future activities. The maturation of technologies to higher technology readiness levels will be guided by technology development agreements signed by the potential users of the technology and the program.

  - Moved the Aircraft Icing Project from the AOS program to the Glenn Research Center-led Propulsion and Power Base R&T Program

  - Integrated the remainder of the research activities of the Space Base (formerly the Cross-Enterprise Technology Development program) into the existing Aerospace Base R&T Programs

    - Highly distributed systems, sensors, nano-spacecraft, nanostructured materials, resilient materials and Advanced Concepts were merged with the Aerospace Vehicle Systems Technology Base Program

    - The Space On-Board Power and Electric Propulsion and Advanced Energy Projects were merged with the Aerospace Propulsion and Power Base R&T Program

- Terminated programs that were evolutionary in nature, had a narrow focus, had not performed well, or did not provide a significant contribution to the Enterprise Goals. Terminated programs included the Rotorcraft and Intelligent Synthesis Environment (ISE) Programs, as well as the Computational Aerospace Sciences (CAS) and NASA Research and Education

Network (NREN) projects in the High Performance Computing and Communications Program. The Power and Communications Commercial Space Centers, the Polymer Energy Rechargeable System (PERS) activity, the Ultra-Low Power Electronics activity, and the Glennon Initiative from the Space Base Program were also discontinued.

- Initiated a new effort, called Design for Safety, within the Computing, Information and Communications Technology area. This research will provide a paradigm shift in how systems engineering and operations will be performed, and aims to place risk estimation and risk countermeasures for overall mission and human safety on a more rigorous, explicit, and quantifiable basis. This new paradigm would allow design trades to be evaluated based on a risk factor, with the same fidelity and confidence used for other mission or system properties such as cost, schedule, and performance.

- Initiated a new effort, Virtual Airspace Modeling under the Aviation System Capacity Program, to model the airspace environment. In order to meet the demands for the airspace system of the future, a revolutionary change in the fundamental approach to airspace operations will be required. This modeling effort will provide the technical basis to guide policy by exploring revolutionary concepts and technologies, identifying those offering the greatest potential benefit, as well as their limits.

- Initiated a new effort, in the Vehicle Systems Base R&T Program, to develop the technologies needed for a 21st Century Aerospace Vehicle. This research will develop and verify critical technologies that provide leapfrog capabilities to today's state of the art vehicles. These new vehicles might be able to change their shape in flight –" like birds"-- to optimize performance or perform complex maneuvers in complete safety. They might be capable of self-repair when damaged, and has limited impact on the environment. These types of vehicles will require significant advances in technology such as biotechnology and nanotechnology sensors, materials, and computational sciences.

- Implemented five University-based Research, Education, and Training Institutes (RETIs). The RETIs will strengthen NASA's ties to the academic community through long-term sustained investment in areas of technology critical to NASA's future. At the same time the RETIs will enhance and broaden the capabilities of the nation's universities to meet the needs of NASA's technology programs. The role of the RETIs is intended to be research and exploitation of innovative, cutting-edge, emerging opportunities for science and technology that can have a revolutionary impact on the missions that NASA pursues in the future. At the same time the RETIs should expand the nation's talent base for research and development. To ensure the highest quality research and training and infusion of new ideas, these RETIs will be subject independent, external reviews and recompetition at regular intervals, including mandatory sunsets after ten years. To ensure the high quality research, the program will be subject to external independent reviews and a significant potion of the research will be externally competed. To endure strong ties to technology customers, a team of potential internal and external users will assess the relevance of the research to future NASA and commercial/government applications and provide recommendations for ongoing and future activities. The maturation of technologies to higher technology readiness levels will be guided by technology development agreements signed by the potential users of the technology and the program.

- Initiated a new effort in Aerospace Autonomous Operations. This research will enable better, faster, cheaper, more reliable aerospace missions by extending the scope of decisions and actions that can be done under computer control. The research enables unmanned missions to accomplish more by making better autonomous decisions, including a health monitoring system with real time fault detection, isolation and recovery, a robust situational awareness with the ability for real time mission replanning and rescheduling. It will enable manned missions to be cheaper and safer by providing more sophisticated interactions between astronaut and machines. Finally, it will enable ground operations to be cheaper and faster, by allowing a reduced ground operations team to send more-complex, higher level instructions. To ensure the highest quality research and strong ties to NASA's missions, Aerospace Autonomous Operations investments will be guided by technology development agreements signed by customers in other NASA Enterprises and will be subject to external, independent reviews. A significant portion of these investments will be externally competed.

- Initiated new efforts in biotechnology and nanotechnology -- the true revolutionary technologies of the 21st Century. Systems using these technologies have no counterpart today. Nanotechnology-based aerospace materials, are lighter and have the potential to be 100 times stronger than steel at one-sixth the weight. Combined with biology-inspired processes, they could be made to self-assemble to a pre-designed shape, self-repair when damaged, and continuously, optimally modify their internal structure in response their operating environment. Bionanotechnology computing and electronics can provide capabilities orders of magnitude better than the best of today's electronics. For comparison, in terms of computing power of the human brain is about 10,000 times more capable than the best "silicon" computer and much more power efficient. It can perform up to 1000 trillion operations per second and consumes only about 10 watts of power. These technologies may also enable sensors and detectors, that could be sensitive to a single photon or electron; and they could enable spacecraft systems to be much smaller, with higher performance, and lower power consumption than is possible with today's technology. To ensure the highest quality research and strong ties to NASA's missions, these investments will be guided by technology development agreements signed by customers in other NASA Enterprises and will be subject to external, independent reviews. A significant portion of these investments will be externally competed.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF AEROSPACE TECHNOLOGY **AEROSPACE RESEARCH & TECHNOLOGY**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Research and Technology Base program	563,866	564,726	637,000	SAT 4.1-2
Aerospace Investments	-----	11,200	-----	SAT 4.1-37
Fundamental Space Base program	-----	98,184	-----	SAT 4.1-38
Aerospace Base NASA Research Announcements (NRA) program	-----	39,912	-----	SAT 4.1-39
Focused programs	421,529	527,636	720,600	SAT 4.1-40
Aerospace Institutional Support	[708,953]*	[810,359]*	871,239*	SAT 4.1-89
Total	985,395	1,241,658	2,228,839*	
	[1,694,348]*	[2,052,017]*		
Distribution of Program Amount by Installation				
Johnson Space Center	2,698	7,838	9,968	
Kennedy Space Center	6,716	7,894	31,910	
Marshall Space Flight Center	202,934	231,221	444,926	
Stennis Space Center	36,738	27,563	36,074	
Ames Research Center	203,249	272,572	448,454	
Dryden Flight Research Center	100,618	99,857	141,983	
Langley Research Center	193,131	246,687	482,026	
Glenn Research Center	186,105	238,361	391,287	
Goddard Space Flight Center	6,194	27,581	43,440	
Jet Propulsion Laboratory	6,284	28,745	36,175	
Headquarters	40,728	53,339	162,596	
Total	985,395	1,241,658	2,228,839*	

* Funding includes direct-program Institutional Support to Aerospace Technology Enterprise (from FY 2001 President's Budget, Mission Support section)

BASIS OF FY 2002 FUNDING REQUIREMENT

RESEARCH AND TECHNOLOGY BASE

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Information Technology ..(*realigns to CICT in FY 2002*)	74,346	118,410	-----
Construction of Facilities (Included above) -----	*[6,*	*000]*	-----
Computing, Information, & Communications Technology (CICT)	-----	-----	195,283
Construction of Facilities (Included above) -----	-----	*[6,*	*000]*
Vehicle System Technology	148,819	151,641	157,457
Propulsion & Power	78,495	85,768	94,840
Flight Research	71,203	83,266	82,384
Aviation Operations Systems **	17,000	17,437	-----
Rotorcraft	26,900	31,584	-----
Space Transfer & Launch Technology	95,203	76,644	67,036
Construction of Facilities (Included above) -----	*[10,*	*000]*	*[11,974]*
Minority University Research and Education Program ***	7,200	[11,200]	-----
Construction of Facilities	14,700	-----	-----
Future Space Launch Studies	30,000	-----	-----
Fundamental Space Base	[101,275]*	[98,184]*	-----
Aerospace Base NRA's	[40,000]*	[39,912]*	40,000
Total	563,866	564,726	637,000
	[705,141]*	[714,022]*	

* The total including Space Base Program as proposed in a transfer, beginning in FY 2001. This total is an accurate reflection of the Space Base – Aerospace Base merger, $705,141K in FY 2000 and $714,141K in FY 2002.
** Realignment in FY 2002 splits program to CICT and Propulsion & Power Programs.
*** Minority University Research and Education Program funding realigns to their respective base program's budget

PROGRAM GOALS

The goal of the Aerospace Research and Technology (R&T) Base is to develop the high payoff revolutionary technologies that will be required to support 21st Century Aerospace Vehicles and National Aerospace System. Also to provide the vital foundation of expertise and facilities that consistently meets a wide range of aeronautical and space transportation technology challenges for the nation. The R&T Base will pioneer the development of new breakthrough technologies such as nanotechnology and to consistently push the boundaries of our knowledge to explore the technologies that will lead to the next paradigm shift for aerospace systems. The R&T Base is also charged with ensuring the core competencies within and outside NASA's research centers that are necessary for NASA to accomplish its mission now and into the next millennium.

The Aerospace R&T Base operates and maintains research facilities operations and provides expert consultation for NASA Enterprises, industry and other agencies during their product development design and build processes. The R& T Base continues to sponsor and conduct research using cooperative programs, not only to leverage resources for technology development, but also to ensure timely technology transfers to U. S. customers.

In addition, the Aerospace R&T Base supports crosscutting technology requirements for all NASA Enterprises. The technologies are generally broadly applicable to many potential missions and systems and focus on the early stages of the technology life cycle. Technologies developed under the program provide the foundation for most new vehicle, spacecraft, sensing, robotics, and information technologies eventually flown on NASA missions, and also provide the primary source of advanced concepts and technologies to enable breakthroughs in aerospace transportation. Potential customers throughout NASA's Enterprises are involved as advisors in the planning of research activities. Evaluation and insertion of emerging technologies and concepts for application to higher level mission system concepts and prototypes, and eventually to mission use closely coordinated with potential Enterprise users.

The five fundamental research programs provide the foundation of aerospace research for NASA. They cover all flight regimes from general aviation and commercial transports to high performance aircraft, reusable launch vehicles, and other space transportation vehicles. They address fundamental knowledge and long-term opportunities and have long-term horizon set on the 25-year goals. The broad mix of long-term, high-risk, high-payoff technologies provides many potential options for achieving the goals. While the fundamental research programs provide the basis for the applied research programs of the future, in some cases the technology transitions directly to the customer. The fundamental research programs serve as the vital foundation for the Enterprise's National resource of expertise.

STRATEGY FOR ACHIEVING GOALS

A major restructuring and replanning of the Aerospace Enterprise's Base R&T Base was accomplished during 1999 to begin the integration of the Enterprise's existing space transportation and aeronautics Base R&T development programs into a single entity. This restructuring effort has continued, and in the latest proposed change, the Aerospace & Space Fundamental Base (formally

Cross-Enterprise Technology) programs are being integrated and similar Aerospace Base R&T efforts consolidated. This restructuring better aligns the required technology development efforts with core competencies, reduces management overhead, and brings the expertise, resident in the aeronautics research centers, to bear on the technological challenges associated with space transportation and spacecraft systems. Secondly the integration of the space and aeronautics development needs results in a synergistic technology development plan that better utilizes our resources, eliminates duplication of effort, and allows multiple users, including the space transportation, aeronautics, and the other NASA Enterprises, to be included as part of the planning process. And finally, the character of the resultant program will become more innovative and revolutionary through the changes in the content and focus of individual activities.

Continuous advances characterize the technology environment for success in aerospace across a wide range of disciplines, as well as developments of revolutionary technology. The R&T Base is critical to technological preeminence in the worldwide aerospace market. Through basic and applied research in partnership with industry, academia, and other government agencies, NASA develops critical high-risk technologies and advanced concepts for U. S. aircraft, spacecraft, launch vehicles, and advanced turbomachinery-based engine industries. These advanced concepts and technologies allow new generations of environmentally compatible, reliable, safe, and economical U.S. aircraft, spacecraft, and launch vehicles that are competitive in the marketplace.

The R&T Base is an essential element of the Enterprise, for it is here that new technologies that lead to future advanced aerospace products are conceived. The R&T Base provides a strong foundation for the fundamental understanding of a broad range of physical phenomena, the development of computational methods to analyze and predict physical phenomena, and experimental validation of key analytical capabilities. It is this capability that allows NASA to provide authoritative data to national policy makers in areas such as the environmental impact of aerospace systems. The R&T Base also develops revolutionary concepts, highly advanced, accurate computational tools and breakthrough technologies that can reduce the development time and risk of advanced aerospace systems and high-performance aircraft. A significant portion of the research and concept development in the R&T Base is performed through partnerships and cooperative agreements with the aerospace industry and other government agencies to facilitate rapid technology transfer. Also, the R&T Base supports the vast majority of the Aerospace Technology Enterprise's peer-reviewed fundamental research with academia and industry. The program also provides the capability for the Enterprise to respond quickly and effectively to critical problems identified by other NASA Enterprises, agencies, industry or the public. Examples of these challenges are found in: investigating accidents; determining lightning and radiation effects on avionics; improving flight safety and security; analyzing wind shear; studying crew fatigue; reducing environmental impacts of aeronautical systems; analyzing the causes and effects of structural fatigue; resolving spacecraft/launch system anomalies; and researching the causes of aircraft stall/spin.

The goals, objectives, and progress of the Aerospace R&T Base are evaluated on a yearly basis by an external, independent panel of nationally recognized experts. These external reviewers ensure that program content is consistent with the Enterprise's Strategic Plan, and that the program is yielding the maximum possible return on the taxpayers' investment. An additional annual review is conducted by an independent Inter-Center Systems Analysis Team that provides an assessment of each R&T activity's contribution to the accomplishment of the Enterprise's Goals.

- One of the key factors in aerospace research is an extensive use of facilities and R&D expertise that is located at the four research centers—Ames Research Center, Dryden Flight Research Center, Langley Research Center, and Glenn Research Center—and at other NASA Centers including the Marshall Space Flight Center (MSFC), Jet Propulsion Laboratory (JPL), Goddard Space Flight Center (GSFC) and Johnson Space Center (JSC). Many facilities and R&D capabilities at these centers are unique in the United States and even the world.

The Aerospace Technology R&T Base is a framework of five systems oriented, customer driven programs, that serve the needs of the full range of aerospace vehicle classes. The five R&T Base programs are:

- Computing, Information & Communications Technologies (CICT) Program will provide essential new enabling capabilities and specific deliverables to fulfill high-priority multi-Enterprise needs for future missions. CICT will provide tangible benefits to NASA missions of the future. These benefits include more rapid, safe and cost-effective mission planning and scheduling; more capable and resilient aerospace platforms; increased mission assurance through the delivery of more dependable avionics software; reduced need and support costs for "standing armies" of mission controllers currently required on a 24-hour by 7-day basis for international space station and selected deep space missions; and faster and cheaper high-performance computing and networking for the development, analysis and understanding of very large and complex NASA data sets. Example data sets would include aerospace, astrophysics, Earth science and astrobiology.

  The CICT program encompasses the following programs.

  - Information Technology Base
  - Aerospace Autonomous Operations
  - Bio-Nano Computing technology
  - Design for Safety
  - Aerospace Operations Research
  - Intelligent Systems

  The CICT includes a spectrum of investments that are needed for the Agency's missions. To ensure the high quality research, the program will be subject to external independent reviews and a significant potion of the research will be externally competed. To ensure strong ties to technology customers, a team of potential internal and external users will assess the relevance of the research to future NASA and commercial/government applications and provide recommendations for ongoing and future activities. The maturation of technologies to higher technology readiness levels will be guided by technology development agreements signed by the potential users of the technology and the program.

- Vehicle Systems Technology (VST): The VST program will pioneer the identification, development, verification, transfer, and application of high payoff aeronautical, space transportation, spacecraft, and science sensing systems technologies. Emphasis is on areas such as conceptual design; aerodynamic and structural design and development; smart materials and structures; flight crew station design; systems design and testing, and third-generation space transportation. Nano-structured materials technology is being investigated to enable tailoring, at the molecular level, breakthrough materials that will provide vast improvements in resiliency, life, and physical properties. Methods are sought to enable highly distributed, interactive, in-space and ground-based (Earth and planetary) sensing and observation networks that provide broad, continuous, and selectable coverage and maximum economies of launch and ground resources via advanced micro-systems, ultra-sensitive sensors, and shared duties. Advanced concepts for new future missions are both developed in-house and are solicited via an openly competed award process operated by an independent university-led center.

- Aerospace Propulsion and Power Technology: the purpose of this program is to conduct research in order to design and develop propulsion and power systems for a wide variety of applications. The technology areas include engines which will enable and ensure environmental compatibility and improve the safety and efficiency of the global air transportation system, systems for access to space, and systems for operating in space and on planetary surfaces. The program addresses critical air breathing, chemical and electric propulsion technology needs across a broad range of aerospace vehicle classes. For in-space operation it explores advanced methods for conversion of energy from solar and non-solar sources to on-board power and for the efficient storage and management of onboard power for space vehicles. This program also includes NASA's aircraft icing research activities.

- Flight Research: The objective of this program is to safely enable, conduct, and improve NASA's atmospheric flight research. The program promotes technology innovation, discovery of new phenomena, and the accelerated development of new aerospace concepts. Experimental aircraft and tools for aerospace innovation provide a mechanism to validate design tools and new technology. The early development and validation of new concepts are undertaken in a realistic environment, allowing lower cost development and more rapid transfer/ infusion of technology. Elements within the Flight Research Base R&T Program include:

  - The Environmental Research Aircraft and Sensor Technology (ERAST) project, which develops very-high-altitude/long-endurance, remotely piloted aircraft technology.
  - Revolutionary Concepts (RevCon), which will conduct flight research into advanced vehicle concepts.
  - Specific flight research activities, which are carried out on dedicated experimental aircraft such Active Aeroelastic Wing (AAW) and testbed aircraft such as the F-15B, and F/A-18.

Space Transfer & Launch Technology (STLT): The STLT program is the technology-base program for unique space transportation requirements. Future revolutionary advances in space transportation technology will be developed in this program to reduce costs, and increase reliability and performance for future launch systems. Advanced technologies will be developed and ground-tested to bring them to readiness levels where they can either be adopted by NASA missions and industry, or if necessary, flight-proven. Elements within the STLT program include:

- Advanced Launch Technologies – Development of technologies which advance the state-of-the-art in propulsion, airframe and launch vehicle systems, operations and integrated vehicle health management towards the long-term Aerospace Technology

Enterprise's Goal 9 technology objectives. Technology priorities are derived from the contribution to overall transportation system goals. .

- Space Transportation Research – Research into very advanced, breakthrough concepts for revolutionizing space travel.

Prior to FY 2002, the Rotorcraft Program was included in the Aerospace R&T Base. This program sought to enable new vehicle concepts for vertical flight that alleviate airport congestion & delays and provide true door-to-door mobility for the traveling public. -After consideration of research priorities to relieve air system congestion within Aerospace Technology budget constraints, this program will be terminated at the end of FY 2001.

Also prior to FY 2002 the Intelligent Synthesis Environment (ISE) was included in Information Technology. ISE sought to radically change the manner in which NASA designs, develops and operates its flight systems and was focused on providing the research, development, acquisition, validation, demonstration and implementation of the revolutionary engineering and science tools and processes needed to fulfill the NASA Administrator's vision for revolutionizing next generation science and engineering capabilities. Due to rapid advances in commercial technology and budget constraints, this program will be terminated at the end of FY 2001, though key elements of the program will be folded into other related activities.

SCHEDULE AND OUTPUTS

COMPUTING, INFORMATION & COMMUNICATIONS TECHNOLOGIES (CICT)

INFORMATION TECHNOLOGY BASE

Real-time Data link for Airspace System Plan: June 2000 Actual: June 2000	Demonstrated multi-protocol technology for real-time data link between aircraft, satellite and ground. This eliminates the need for many separate data streams, and sets the stage for a shared bandwidth where safety and flight-critical data are guaranteed a high-priority distribution among the various types of data being transmitted
Demonstrate heterogeneous distributed computing environment Plan: September 2000 Actual: September 2000	Demonstrate tools and software to link distributed computing test-beds at multiple NASA Centers into a single "virtual" supercomputing environment. Demonstrated prototype heterogeneous distributed computing environment. Developed the underlying computing and data management fabric that will enable the aerospace environments of the future. Takes advantage of the large distributed computing/data developments that NASA has implemented for all Enterprises
Next Generation Intelligent Flight Control System Plan: June 2002	Develop and demonstrate in flight next-generation neural flight control technologies for aircraft and reusable launch vehicles. This will lower development costs, allow for rapid integration of improvements, and allow aircraft to recover from damage in flight.

Virtual Flight: Rapid Integration and Test Environment Plan: December 2000 Actual: December 2000	Demonstrated an environment for aerospace hardware designs that included remote connectivity and access to flight simulation data, computational simulation data and archival databases. This process established an environment where a vehicle design is accomplished rapidly through an integrated vehicle design process, to incorporate pilot-in-the-loop considerations early into the design process and to rapidly incorporate design modifications
Demonstrate ability to adapt to loss of control surfaces and maintain control of aircraft Plan: March 2001	Combine Propulsion Controlled Aircraft (PCA) control laws with the Intelligent Flight Control System (IFCS) to demonstrate a new capability for adapting to absence or loss of any and all control surfaces resulting from failures or malfunctions up to and including propulsion only flight. This activity adds an assisting intelligence to the cockpit, beyond the presence of human pilots, enabling the human crew to operate a severely crippled aircraft safely under conditions, which would normally result in loss of the vehicle.
Remote Access to High Data-rate Instruments Plan: September 2001	Demonstrate remote connectivity to high data-rate instruments and distributed real-time access to instrument data. Integrates the acquisition of aerospace data resources with their management and knowledge extraction on the distributed compute fabric of the future.
Demonstrate prototype data communications scheme for NAS Plan: September 2001	Demonstrate a prototype data communications scheme for the National Airspace System.
Improvements in Aerospace Applications Plan: September 2002	Demonstrate improvement in time-to-solution for aerospace applications through high-end computing and end-to-end networking capabilities, enabling the rapid creation, sharing, and distributed analysis of experimental and high-fidelity computational databases in the design of aerospace vehicles and systems
Exploratory Computing Environments for Aerospace Applications Plan: September 2002	Develop prototype environments that are distributed across heterogeneous platforms, are dynamically extensible, and which support collaborative visualization, analysis, and computational steering for distributed aerospace systems with potential applications to other NASA missions. Integrated computing environments will have a large monetary impact on the speed, quality and cost of NASA mission.
Virtual Flight Synthesis Plan: September 2002	Develop capability to redesign aerospace vehicles during flight simulations exploiting high-end computing and advanced information management technologies. This activity combines rapid redesign with single flight test entry, to enable a new model of how flight simulations can be used as a design tool, by dramatically reducing time required for flight simulation during design, and improving fidelity of design with flight simulation data

Space Communication Link Plan: September 2002	Demonstration of Space Communication Link Technology Operating at 622 Mega-bit per second for Direct Space Data Distribution to Users

INTELLEGIENT SYSTEMS

Initial IS Program Assessment Plan: September 2001	Successfully complete reviews of the Intelligent Systems Program by External Technical Review Council and Mission Needs Council
Mars Mission Software Verification Study Plan: June 2002	Complete a case study demonstrating software verification and validation techniques that are applicable to Mars mission software, and benchmark current state-of-the-art. Emphasize automated techniques that improve software reliability. Automated techniques will enable an order of magnitude improvement in speed and cost of verification.
Human-Centered Computing Mars Exploration Rover Plan: August 2002	Participate as part of the MER 2003 flight team applying human-centered computing analysis and modeling techniques to evaluate and improve the man-machine system performance for operations and science. Opening the human-operator bottleneck will allow for increased science return during the brief 90-day lifetime of these rovers.

AEROSPACE AUTONOMOUS OPERATIONS

Assessment of Remote Agent software Plan: March 2000 Actual: March 2000	The Remote Agent software program demonstrated successful autonomous control of the Deep-Space One spacecraft, achieving 100% of objectives. In FY2000 we analyzed the results of the 1999 experiment, improved Remote Agent, and investigated several targets for deployment of the program in future missions. Remote Agent allowed goal-directed commanding and improved reactivity to environmental uncertainty and component failures, thus increasing the overall robustness of the vehicle.
Rover Field Test Plan: May 2000 Actual: May 2000	Performed joint ARC-JPL two-rover field test at Lunar Crater Volcanic Field demonstrating use of 3D science visualization tool to support science planning operations and enabling increased science productivity by providing a virtual Mars environment in which the scientist can access the data and identify targets of opportunity

Next Generation Intelligent Flight Control System Plan: June 2002	Develop and demonstrate in flight next-generation neural flight control technologies for aircraft and reusable launch vehicles. This will lower development costs, allow for rapid integration of improvements, and allow aircraft to recover from damage in flight.

DESIGN FOR SAFETY

X-37 IVHM Flight Experiment. Plan: March 2002	Captive carry flight of vehicle using a model-based health management system to perform real-time faults detection, isolation and recovery while operating on the vehicle's flight computer. This technology will increase vehicle robustness while radically reducing operational ground support.
Aerospace System Reliability and Cost Database Plan: September 2002	Demonstrate a prototype of a reliability and cost database of space transportation and exploration system mission failures. Include the definition of the appropriate taxonomy. Allowing prioritization of program technical activities and continuous analysis for significant or emerging safety trends.

AEROSPACE OPERATIONS RESEARCH BASE

Define effects of in-flight activity breaks on alertness Plan: June 2000 Actual: June 2000	Conducted a full-mission simulation experiment that utilizes in-flight activity breaks as the controlled variable, produced a report documenting their efficacy.
Predicting Error-Vulnerability Plan: June 2000 Actual: June 2000	Documented a formal methodology for analyzing human-automation systems in aerospace and other domains, including the demonstration of its application to a real human-automation problem in civil aviation. This methodology will increase safety by reducing or eliminating design errors which lead to mode confusion and error in the operation of aerospace human-automation systems
Identify and evaluate existing crew strategies for reducing errors in the management of concurrent tasks. Plan: May 2001	Characterize the demands of concurrent task management and patterns of error, and evaluate strategies for reducing and trapping errors. The benefits include developing training methods to better manage concurrent task demands and developing operating procedures to reduce excessive crew demands.

Cognitive/Physiological Tools for Evaluating Human Performance Plan: June 2001	Develop and document new tools and the supporting validation research within the context of concurrent task execution and hazardous states of awareness. The new tools will be used to improve the design, test and validation processes for efficient task management and crew procedures.
Model for Planning Flight Crew Scheduling Plan: June 2002	Develop initial bio-mathematical model enabling prediction of flight crew behavioral performance capability based on sleep and circadian variables to reduce the potential for human error in aerospace operations.

BIO / NANO COMPUTING TECHNOLOGY

Design Nanotechnology components Plan: September 2000 Actual: September 2000	Completed conceptual design of carbon nanotube "transistors" demonstrating 10,000 times size reduction over silicon-based technology, enabling reductions in mass and power requirements for future NASA missions
Controlled growth of vertically aligned carbon nanotubes Plan: September 2001	Develop a combinatorial chemistry approach to define optimum catalyst composition for carbon nanotube growth coupled with an electrical field enhanced nanotube alignment approach. This controlled growth of nanotubes is a necessary step for the development of nanosensors and electronic components.
Nanotechnology Simulations, Manufacturing and Components Plan: September 2002	Demonstrate feasibility of nanotechnology-based chemical and biosensors and of manufacturing approaches for low-power nanoelectronic components

INTELLIGENT SYNTHESIS ENVIRONMENT (ISE)

Baseline design capabilities and verify requirements Plan: September 2000 Actual: October 2000	Defined formats for reporting state-of-the-art and technology gap analysis; baseline NASA state-of-the-art capabilities for each prototype test application; established critical program element needs for each prototype test application (1R08)
ISE Capability Build 1: Proof-of-concept system Plan: July 2001	Near-term, state-of-the-art environment, user interface and infrastructure, validation on three prototype test applications, prototype measurement and assessment techniques

AEROSPACE VEHICLE SYSTEM TECHNOLOGY

Physics-based prediction of airframe noise components Plan: March 2000 Actual: March 2000	Develop physics-based computation of airframe noise components including flap-side edge, slat, and landing gear. Physics of noise generation was identified. Noise reduction concepts were optimized by computation and verified by experiment. Major benefit demonstrated by the use of a advanced low noise slat design with no aeronautic performance degradation
Non-linear composite pressure structure Plan: September 2000	Fabricate and test non-circular composite pressurized structural sub-component and compare with analytical predictions.
Hyper-X Mach 7 Flight 2 Plan: December 2000 Revised : December 2001	Envelope expansion of Airframe Integrated, Dual-Mode Scramjet powered vehicle in flight at Mach 7. The revision of the planned flight is the result of slips in the precursor flight due to late contractor delivery and additional safety testing
Complete Blended Wing Body (BWB) test vehicle Plan: March 2000 Deleted	Blended-wing-body low-speed flight research vehicle prepared and delivered to Dryden Flight Research Center for final validation and testing
Systems Analysis of Short Takeoff and Landing (STOL) & Extremely Slow Take Off and Landing (ESTOL) Plan: June 2001	Complete systems analysis of STOL and ESTOL studies to understand the benefits of these vehicles to the small transportation system.
Demonstration of “smart” panel technology Plan: September 2001 Revised: March 2001	Obtain wind-tunnel performance data of hingeless control surfaces on a Full-span 30% geometric scale “smart” uninhabited combat air vehicle (UCAV) model
Mach 10 Research Vehicle Flight. Plan: September 2001 Revised: June 2002	Demonstrate an airframe integrated, dual-mode scramjet powered vehicle in flight at Mach 10. The revision of the planned flight is the result of slips in the two precursor flights due to late contractor delivery and additional safety testing.
Central Nervous System Validation Plan: March 2001	Real-time piloted simulation validation of the reconfiguration intelligence component of central nervous system

Protocols and Test Methods Needed For Accelerated Testing of Space Transportation Materials Plan: March 2001	Identify testing methodologies and protocols needed for testing of Space Transportation materials.
Hyper- X Mach 7 Flight 1 Plan: June 2001	Demonstrate an airframe integrated, dual-mode scramjet powered vehicle in flight at Mach 7. Schedule includes the impact of late contractor delivery and additional safety testing
Complete Blended Wing Body (BWB) Critical Design Review Plan: June 2001	BWB low speed vehicle passes Conceptual Critical Design Review.
Biologically Inspired Fabrication Plan: June 2001	Identify approaches for fabrication of structures inspired by biology.
Benchmark NTF ground-to-flight scaling on B777 Cruise Wing Configuration Plan: September 2001	Complete National Transonic Facility (NTF) testing of 777 baseline cruise wing configuration and NTF/CFD/flight assessment of cruise condition.
Large-Scale Component Validation of Noise Reduction Technology Plan: September 2001	Validate developed noise reduction technology at large scale to reduce technical risk of future technology implementation.
Highways in the Sky (HITS) and Datalink Infrastructure Facility (DIF) Validation Plan: September 2001	Complete integrated system flight and simulation testing of AGATE HITS operating capability, DIF system, and simplified flight controls.
Design Guidelines and Documentation Plan: September 2001	Publish design guidelines, system standards, certification bases and methods to document lessons learned in the AGATE project
Oscillatory flow control actuators Plan: March 2002	First demonstration of flow control via oscillatory blowing with leading and trailing edge actuators to enable simplified high-lift systems for high aspect ratio wings Simplified high-lift systems can lead to a3% reduction in total weight of a subsonic transport

Unstructured-grid CFD Plan: June 2002	Capability developed & demonstrated for viscous, solution-adaptive system using high-fidelity modeling, generating an unstructured-grid CFD from a geometry model for a complex aerospace vehicle in 1 day.
Aligned carbon nanotubes Plan: September 2002	Demonstrate the feasibility that carbon nanotubes can be fabricated in an aligned configuration
Non-Autoclave composite Plan: September 2002	Demonstrate adhesives for non-autoclave composite processing.

AEROSPACE PROPULSION AND POWER TECHNOLOGY

Demonstrate 900°F SiC sensor on an engine. Plan: September 2000 Actual: September 2000	Commercial-grade, high-temperature sensor demonstrated at 900°F. Pressure sensor was successfully tested in the de-swirl region of the AS 907 engine compressor
Demonstrate 'smart' turbomachinery concepts to minimize pollutants throughout mission cycle. Plan: September 2000 Actual: September 2000	Active combustion control strategy rig demonstrated, 20dB suppression of instability driven acoustic energy.
Complete Inlet Test for Pulse Detonation Engine Flight Research Project Plan: May 2001 Revised: Deleted	Demonstrated unsteady inlet flow performance for PDE ground and flight research tests. Deleted in favor of higher priority activities.
Downselect of ground-based remote sensor technologies for a prototype ground-based system to sense icing conditions. Plan: June 2001	Review, evaluate and select candidate remote sensing technologies, document in a NASA Technical Manual.

Demonstrate viability of hot section foil bearing Plan: September 2001 Revised: August 2001	Complete Core Hot Section Radial Foil Bearing Rig Testing. Proof-of-viability of hot section foil bearing.
Demonstrate the durability of cast Titanium Aluminum (crack resistant blades)for low-pressure turbine applications Plan: September 2001	Provide alloys for turbine aircraft engine blades that are more crack-resistant.
CD-ROM icing pilot training module Plan: June 2002	Produce a self-paced computer-based training module on icing weather training Provide access to in-flight icing hazards to large audience of pilots – supports home use and individual training. Reduce in-flight icing incidents and accidents.
Ultra Safe propulsion technologies Plan: September 2002	Validated structural concepts, which could be further developed into safety-certified, lighter-weight, lower-cost, and more robust containment systems. New composite/hybrid "hard wall" and fabric "soft wall" containment system structural concepts transferred to the AvSP for full-scale evaluation.
Smart low emissions fuel injection system Plan: September 2002	Demonstrate revolutionary fuel injector concepts in flame tube tests. Concepts will utilize advanced technology, including ceramics, MEMS technology, and active control aimed at achieving the 80% NOx reduction goal, and reducing particulate and aerosol emissions.
8-cm ion thruster laboratory test Plan: September 2002	Complete integration and wear test of 8 cm ion engineering model thruster and breadboard Power Processing Unit
Ion engine integration test Plan: September 2002	Conduct integration test of 5-kW PPU with 5/10 kW next-generation ion engine
PDE-combined/hybrid cycle feasibility Plan: September 2002	Quantitative assessment of the performance potential of Pulse Detonation Engine hybrid/combined-cycle propulsion including non-idealized loss mechanisms.
LH2 propulsion concepts Plan: September 2002	Issue report on conceptual application of LH2 propulsion concepts to subsonic transport aircraft, including propulsion system and airframe concept characterizations complete with mission emission characterizations.

High-temperature composites Plan: September 2002	Demonstrate reaction transfer molded polymer matrix composite with 550•F use temperature. (2R10)

AEROSPACE FLIGHT RESEARCH

Demonstrate continuous "over the Horizon" control of remotely piloted aircraft (RPA) Plan: June 2000 Actual: May 2000	Flight demonstration of reliable "over the Horizon" control of RPA utilizing low cost commercial satellite systems. RPA flew a series of direct commands from the ground station as well as a series of way point sets. Demonstrated the ability to extend RPA operating range to 200 nautical miles with continuous command and control.
X-45 Autonomous Taxi Software Plan: September 2000 Actual: July 2000	The taxi algorithms provided for autonomous UAV ground operations for guidance and control, taxi route planning, obstacle avoidance, and air traffic control. The taxi control laws (software) provide for autonomous UAV ground operations for guidance and control, taxi route planning, obstacle avoidance, and air traffic control. The software has been supplied to Boeing for integration in the full X-45 full vehicle software
Demonstrate functionality of autonomous station keeping for a two aircraft formation. Plan: March 2001	Effective system of aircraft that can maintain formation for transport technologies and DoD UCAV capabilities. Establishing practical operability of precision formation flight for drag reduction and consequently for reduced fuel burn.
Complete development of laboratory (heavy weight) energy storage Plan: September 2001	Demonstrate fuel cells with 300 milliamps per square centimeter at a cell voltage of .8 volts and an electrolyzer with 500 milliamps per square centimeter at a cell voltage of 1.6 volts. Provide laboratory validated design tools that will enable flight-worthy energy storage systems capable of supporting high altitude, long-duration solar-powered aircraft for future science and commercial applications.

Demonstrate solar power RPA flight to 100,000 feet Plan: September 2001	Helios RPA is to achieve 100,000 foot-altitude under solar power. Flight validated design tools for solar powered aircraft capable of operating at extreme altitudes at low airspeeds, suitable for atmospheric sampling and commercial applications
Complete development, validation, and flight testing of a differential carrier-phase GPS coupled with an IMU using a Kalman filter. Plan: September 2001	Flight demonstration of capability to measure precise relative position among a formation of aircraft resulting in reduced fuel consumption.
Demonstrate robust taxi Capability with contingency planning for an autonomous vehicle (UCAV). Plan: September 2001	Taxi UCAV Air Vehicle #1 from the hanger to the runway takeoff point with no errors UCAV capable of ground operations in multi-vehicle environments.
Demonstrate turbo-prop RPA capabilities that exceed the minimum ESE altitude and duration requirements. Plan: September 2002	Flight validation of an experimental, consumable fuel, RPA design that will enable an enhanced prototype vehicle to meet the prescribed set of Earth Science Enterprise (ESE) RPA science platform requirements. First flight of the Predator B was conducted in early February 2001. All aircraft systems functioned correctly and development is continuing to meet the milestone

ROTORCRAFT

Flight-demonstrate active control technology for rotorcraft interior noise reduction; provide interior noise prediction methods for a range of rotorcraft types. Plan: June 2000 Actual: June 2000	Demonstrated cabin noise reductions resulting from improved interior panel isolator mount designs and from an active structural acoustic control system concept; validated improved interior-noise analytical prediction tools covering a wide frequency range and alternative designs. Specifically active noise control (ANC) applied to the MD Explorer aircraft demonstrated a 3-4 dB reduction at transmission “bull” gear-mesh frequencies and ANC applied to the S-76 aircraft achieved a 23 dB reduction in maximum cabin noise at the transmission “bull” gear mesh frequency, the major source of noise.

Develop and validate capability for large-scale rotor testing. Plan: September 2000 Actual: September 2000	The Large Rotor Test Apparatus (LRTA) allows wind-tunnel testing of helicopters and tiltrotors up to 50,000 lb. thrust and 6000 HP. Its performance has been validated through operational checkouts and extensive calibration activities. The LRTA provides a unique national capability to test large-scale rotors. This capability is necessary for understanding aerodynamic and dynamic phenomena that can not be adequately predicted or scaled, including rotor performance, dynamic stall, structural loading, and stability.
Rotorcraft Crashworthiness. Plan: January 2001 Revised: February 2001	Demonstration of strong correlation of analytic model predictions with full-scale water/soft-soil-impact test results, demonstration of analytic model for designing energy-attenuating rotorcraft structures for crashes onto water, soft soil and rigid surfaces.
Health and Usage Monitoring Systems (HUMS) Certification Protocol. Plan: February 2001	Detailed protocols for a sanctioned demonstration leading to rotorcraft component-life-credit certification -- accepted by both the FAA and the DoD. RITA diagnostic algorithms will be evaluated and a set of usage requirements will be generated. Preliminary design for HUMS implementation on various aircraft will be written. Plans for a limited flight evaluation of Cockpit Situational Awareness Algorithms will be developed.
Ultra-safe gear design guide. Plan: March 2001	Complete 2-D gear crack analyses and experiments. Document analysis and test results in a comprehensive report and technical conference paper.
Flight-validate advanced control laws/modes for reduced pilot workload and increased safety in low visibility. Plan: September 2001	Achieve Level 1 pilot ratings in Rotorcraft Systems Concept Airborne Laboratory (RASCAL) UH-60 for flying tasks typical of civilian operations. Milestone rescoped to conduct flight validation based on baseline RASCAL control laws due to planned cancellation of Rotorcraft Program in FY 2002.
Rotorcraft Technology Documented. Plan: September 2001	Technology advances achieved in the Rotorcraft Program will be archived and documented for transfer as appropriate to DoD and NASA Aerospace Base R&T and Aerospace Focused programs.

SPACE TRANSFER & LAUNCH TECHNOLOGY (STLT)

LOX Densifier verification testing and completion of hydrogen densifier build Plan: June 2000 Actual: October 2000	Validate design, technology and operational characteristics of X-33-scale liquid oxygen propellant densifier, and prove readiness for use in experimental propulsion ground test or flight test program. Completion of Hydrogen densifier assembly. The LOX densifier was demonstrated at 30 lbs./sec and the assembly of a 8 lb./sec liquid hydrogen densifier was completed.
Complete fabrication of Metal Matrix Composite (MMC) & Polymer Matrix Composite (PMC) thrust cell chamber demonstration units Plan: August 2000 Actual: August 2000	Will demonstrate successful fabrication of thrust cell chambers using new material systems that offer weight savings up to 40%. Based on the subscale chamber fabrication and testing of three polymer matrix and two different metal matrix materials, demonstrated feasibility of reducing current thrust chamber weights by more than 50% by applying composite materials. Each unit used composite materials for the chamber's structural jacket. Additionally, an advanced copper alloy was used for the hydrogen cooled chamber liner.
NSTAR Engine ground demonstration Plan: September 2000 Actual: May 2000	Complete NSTAR Mission Profile (100% design life) ground testing for Deep Space-1 (concurrent, identical firing of an NSTAR engine in a vacuum chamber with the actual firing sequence of the in-flight propulsion system). Demonstration of 100% design life (87-kg xenon throughput) ground testing of the sister engine used for the Deep Space-1 mission was achieved when the engine had accumulated 10,375 hours of operation
Advanced TPS panel development, fabrication and test Plan: September 2000 Actual: September 2000	Demonstrated the utility of low-cost casting / rolling process for fabricating Titanium-Aluminum sheet (0.025 in thick), developed brazing and diffusion parameters, and fabricated truss-core ad honeycomb core from a nickel based alloy. Honeycomb sandwich panels were fabricated and successfully tested. Characterized a family of Conformable Reusable Insulation based on testing including arc jet and wind tunnel tests and includes effect of humidity exposure, wind/ rain exposure, radiant heat exposure, drop impact, repair, and re-waterproof.
Composite Cryogenic Tank and Integrated Structures Demonstration Plan: July 2001	Validation of PMC cryogenic LH2 and LOX tanks to include validation of compatible materials systems and processes, fabrication and joining of large-scale articles, and demonstrated thermal-structural performance. Significant weight reduction for RLV cryotanks and primary structure can be quantified through actual test data.

Complete preliminary design of LOX tank for X–34 Plan: March 2000 Actual: January 2000	Hold preliminary design review of composite LOX tank for X–34. PDR was completed which included completion of the system and test requirements, conceptual design, component test definition, and test structure design.
RBCC Demonstrator concept design complete Plan: September 2001	Baseline concept for RBCC demonstrator will be established
Initial Flowpath Definition and Testing Completed for RBCC Demonstrator Plan: September 2001	Initial flowpath characterization complete. Used as criteria for combined cycle demonstrator engine selection.
RBCC Demonstrator SRR Completed Plan: June 2002	Successfully complete Systems Requirements Review on RBCC Demonstrator Engine. Requirements established for the ground demonstrator engine

ACCOMPLISHMENTS AND PLANS

Computing, Information & Communications Technologies (CICT)

In FY 2000, The IT Base Program demonstrated the first-phase prototype of a geographically-distributed heterogeneous high-end computational grid testbed to meet future NASA supercomputing requirements. The testbed integrated recent advances in computing hardware, network technologies, and system software that allows seamless and transparent access to testbed assets. The integration of these technologies allowed for geographically dispersed engineering collaboration and greater peak computing power, enabling improved time-to-solution for a range of NASA applications including, for example, the X-38 vehicle. The IT Base Program also completed a demonstration of real-time aerospace design exploration in FY00. The developed environment includes remote connectivity, access to experimental data in real- time, capability to perform simulations in near-real-time, and access to databases with analysis tools to support design. All of these capabilities have been coupled with newly developed instrumentation and data systems to provide previously unavailable experimental data to the aerospace vehicle designer. New capabilities include non-intrusive measurements of molecular flow, instantaneous detection of turbulent flow structures, advanced acoustical measurements and accurate spatial detection of experimental model attitude and deformation. In addition to reductions in access time to high-fidelity simulation data, specific improvements of the system include a reduction in access time to experimental data by more than a factor of five, and a reduction in access time to archived database sources by a factor of two. IT Base improvements in software technology included the development of verifiably correct automatic code generation (program synthesis). Tools developed/matured in this activity demonstrated a reduction in time required for software coding and testing, enabling new implementations to be generated in minutes for design changes that would formerly require days of re-coding. Moreover, the tools automatically generated detailed documentation explaining the implementation. Specifically targeted applications in aerospace guidance and navigation software were used to demonstrate these tools on real-world, complex software development activities meeting NASA mission requirements. The generated code consisted of calls to hundreds of software components. Also as part of the IT Base R&T Program, the Search and Rescue project (a Cospas-Sarsat satellite-based search and rescue system) was designed and developed in the 1970's by NASA and launched in the 1980's, with plans being developed for a replacement system. The objectives are to reduce the waiting time (to minutes from current 2 hours at the equator), false alarm rate (high currently), and number of ground stations. The U.S. National Search and Rescue Committee (NSARC), of which NASA is a member, has identified a possible opportunity to achieve such a capability through a partnership between the U.S. DoD, DoE and NASA. NASA is responsible for SAR R&D. During FY 2000, a preliminary concept was defined that enables ground stations to provide unambiguous location of distress beacons within 2 minutes with location error of about 6 to 7 km, and below 4 km after less than 5 minutes. The system has an ultimate potential of errors below 0.5 km in 2 minutes. The IT Program demonstrated Microwave Micro-Electro Mechanical Switches (MEMS) with 60% lower loss than conventional switches have been demonstrated. This improvement has significant impacts on antenna efficiency and cost for upcoming high rate phased array antennas needed for NASA Near-Earth missions. High performance printed antennas are particularly attractive for space applications because of its planar structure and lightweight. Enhancing the gain, bandwidth and functionality of an antenna will reduce the number of elements required in an array and improves the capacity of the communication systems. A 4x4 printed array with a suspended microstrip feeding-network was demonstrated at Ka-band. Measured results indicated 4-5% efficiency improvement and 2% bandwidth improvement as compared to standard microstrip corporate feeds. These antennas, with multi-function capability, can be used for multi-beam array applications

In autonomy as part of the Space Base Program, the first joint Ames-JPL rover field test was performed using both the Ames K-9 and JPL FIDO rovers. Over 3 days, the K9 rover executed 12 command cycles, traveled about 6 kilometers and yielded 3D models of 3 target rocks. In addition, it demonstrated the use of 3D visualization to help in science experiment planning and target selection. The Remote Agent Experiment was also completed following a successful experiment demonstrating for the first time the use of advanced artificial intelligence techniques to autonomously control a deep space mission using goal-directed commanding. In FY00, a full assessment of the Remote Agent Experiment was performed identifying both the key accomplishments as well as the existing limitations in the technology. Work was begun to address these limitations and to mature the component technologies for deployment within a number of on-going experiments.

During FY 2000, the focus of the Aerospace Operations Systems (AOS) was on developing more basic concepts, procedures and systems to remove the key barriers to significant improvements in the safety of the nation’s aviation system. Based upon a simulation study with airline flight crews, in-flight crew activity breaks were found to be effective as a countermeasure for pilot fatigue. The simulation study demonstrated that brief, hourly in-flight activity breaks reduce subjective sleepiness for up to 40 minutes during the circadian trough, reduce physiological sleepiness for at least 15 minutes during the circadian trough, and are valued by flight crews to be practical and operationally feasible. In operations research, a theory-based methodology for predicting operational error vulnerability was developed. The methodology defines the connection between a machine’s behavior, the task specification, the required user interface, and the user-model to ensure that correct and unambiguous interaction between a user and a machine is possible. In particular, the methodology enables the analysis of a given display and user-model for a specified task.

Finally, in FY2000, Bio/Nanotechnology theorists conceived carbon nanotube "transistors" four orders of magnitude smaller than possible with silicon technology. Experimental breakthroughs included development of Chemical Vapor Deposition methods to form nanotubes in a controlled manner (for example formation of nanotubes between pillars, growth of nanotubes in linear bundles and in-situ growth of nanotube tips for Atomic Force Microscopes). Other experimental breakthroughs during the year included use of protein nanotubes as "backbones" for self-assembly of new nanostructures. Each of these experimental achievements represents great progress toward creating new nanomaterials and nanosystems. An agency-wide team and representatives from industry and academia met in January 2000 to assess the strategic impact of nanotechnology on NASA's missions. This team determined that nanotechnology has enormous potential to revolutionize the way NASA conducts its business in each of its enterprises. Furthermore, a new multi-agency/multiple center cooperation effort with partnerships in nanotechnology development, was put in place. NASA has taken the lead in the grand challenges for spacecraft systems, aerospace structures and materials and is a senior partner in the areas of nanoelectronics and nanosensors.

FY2001

In FY2001, IT Base Program research in advanced computing will reduce turnaround time for aerospace vehicle design and simulation. These improvements will be partially supported through the development of new software tools to measure computing testbed and network performance, database manipulation, and resources scheduling. These tools are needed in order to evaluate alternate scheduling strategies and choose optimal approaches to reduce the variability and improve the predictability of distributed supercomputing resources. These tools will also be used to evaluate new, innovative supercomputing concepts. In addition, IT Base will complete the development of software tools to reduce the time required to adapt applications to new supercomputing systems and tools to enhance network performance. These technologies will enable access to distributed computing systems and on-demand connectivity to high data rate instruments, leading to enhanced engineering and scientific collaboration among geographically-dispersed investigators. These capabilities are likely to impact not only aerospace vehicle and system design, but also NASA science investigations and other applications requiring distributed collaboration, high-end information and computing resources, and access to high data rate instruments. Also, the IT Base Program will demonstrate an environment for aerospace hardware design that will provide real-time access to flight simulation data during a flight simulation test, with computational simulation data available as input to the flight simulation. This research will provide a capability for assessment of design impacts on aerospace vehicle controls and handling qualities earlier in the design cycle, leading to reduced design costs and improved designs. A cross-fidelity aerospace design system being developed in the IT Base program will enable the use of high-fidelity modeling codes in a design paradigm focused on rapid turnaround of computational simulation solutions.

The demonstration of a Intelligent Life-Extending Engine Control will yield substantial increases in aircraft engine lifetimes, resulting in reduced life cycle costs for maintaining a fleet of aircraft. Software technology being developed by the CICT program will result in increases in safety and productivity for the National Airspace System. Work done previously in Intelligent Flight Controls will be extended into Propulsion Controlled Aircraft control laws and will demonstrate a capability to adapt to loss of any and all control surfaces resulting from failures or malfunctions, up to and including propulsion-only flight. This work forms the basis for the technology integration effort being planned for future work in aerospace autonomous operations. This technology can dramatically increase the safety of commercial aircraft. A satellite-based system for air- ground communications using multiple protocols will provide increased situational awareness capability both in the cockpit and on the ground. Finally, the IT Base Program will begin development of network protocol software modules to provide reliable multicast communications in satellite-based IP networks to increase network efficiency and reduce the costs of data transmission. This effort, for the delivering space-based multicast services, will involve the development protocol schemes at the link and transport layers. A new transport layer protocol will be developed to mitigate the effects of long propagation delays and satellite system error rates to support real-time applications in networks with high delay-bandwidth products and high-bit error-rates. Exploratory research will also be conducted to address data-compression, memory efficiency, intelligent routing, and network protocols for high-speed proximity networks will be developed. NASA will design, fabricate, and characterize bit phase shifters: low loss-rate, bandwidth efficient, radiation-hardened digital modulator application specific >50% magnitude from current state of the art. In addition, NASA will support initiation of the development of a proof-of-concept Search & Rescue system to demonstrate that identified performance potential can be achieved. MOUs between the USAF, NASA, and DOE, and other agreements with appropriate agencies are presently under development.

Several Design for Safety (DFS) workshops were held during FY2001 to refine the current understanding of system and mission failures of NASA aerospace and exploratory missions, along with potential solutions from government, industry, and academia. The first workshop was Design for Safety (DFS2000), which included nine technical sessions, with speakers from all NASA centers, aerospace companies (United Space Alliance, Honeywell, Loral, Lockheed Martin), information technology companies (In-Q-Tel Corporation, Lotus/IBM), academia (MIT, Stanford, Carnegie-Mellon, Rutgers, Georgia Tech, UC Berkeley) and other Government agencies (DOD, NSF, USAF and the FAA). Subsequent workshops were held, including the Resilient Systems & Operations workshop held at Dryden Flight Research Center in November 2000. The main products of the RSO workshop were a clear identification of Resilient Systems & Operations goals for flight control, ground systems, and diagnostic technologies that would adapt to known and unanticipated hazards. Additionally, plans for a partnership with the Air Force Research Laboratories were established, in the areas of concurrent airspace operations.

Aerospace Operations System (AOS) research in FY2001 will concentrate on developing an understanding of the causes of errors during concurrent task management, with an eye towards future development of training tools to alleviate this type of error. Fundamental modeling of human performance and the interaction of human operators with automated systems will continue. Tools will be developed and documented for evaluating human cognitive performance within the context of concurrent task execution and awareness of hazardous states. These tools are developed using a combination of empirical investigation, modeling, and direct measurement of brain activity.

Finally, Bio/Nanotechnology efforts in FY2001 will focus on the design and development of viable nanodevices based on carbon nanotubes for electronic and sensor applications. A variety of carbon nanotube configurations as electrodes and biosensors have been examined and compared to conventional carbon paste electrodes. A key advance has been the development of purification techniques to remove amorphous carbon from carbon nanotubes in order to improve signal-to-noise ratio in sensor applications. In addition, methods have been developed for the production of protein nanotubes.

FY2002

In FY2002, the IT Base element of CICT will continue to develop a seamless distributed computing and information system to support increased fidelity, higher confidence and reduced time-to-solution for aerospace applications. Collaborative visualization and computational steering across a heterogeneous distributed system will be demonstrated. IT Base will demonstrate these capabilities within relevant NASA aerospace design activities, including advanced space transportation vehicles. Along with these computing advances, IT Base will continue to develop improvements in advanced networking for NASA's future needs. Efficient network utilization through multicasting will be demonstrated. Quality of service and traffic engineering capabilities that allow for prioritization and assurance of network availability will also be demonstrated. The IT Base element will develop key capabilities for advanced safety and design concepts. This includes simultaneous acquisition, analysis and display of data from disparate instruments, as well as improvements in the quantity and quality of instruments used in an aerospace testing environment. The integration of advanced flight simulation facilities into a triad of aerospace vehicle design assets (together with experimental test facilities and high-fidelity computational capabilities) will be completed with the demonstration of an aerospace vehicle redesign during a single test entry within a flight simulation facility. Finally, IT Base accomplishments in high dependability software will include a demonstration of a factor of 10 improvement in automated techniques for scalable software verification. The IT Base will also develop, integrate, and demonstrate on-orbit a novel programmable Surface Acoustic Wave (SAW) correlator integrated into an advanced Microminiature SAW-based Wireless Instrumentation System (Micro-SWIS). The programmable SAW correlator addition to state-of-the-art very low power micro-radios will provide spread-spectrum benefits that are adaptable in real-time to the environment. It will allow much higher data rates and numbers of Micro-SWIS units to simultaneously communicate by radio. Of special interest for space applications, it allows Micro-SWIS real-time network and measurement synchronization in a harsh environment. In addition, we continue to support proof of concept development for a replacement Search & Rescue Spacecraft leading toward the completion of system definition in FY 2005

The Design for Safety (DFS) element of CICT will build a prototype of a reliability and cost database of aerospace system missions, including the definition of the appropriate taxonomy. This prototype would serve as a foundation for an infrastructure to map system safety problems and uncertainties to information technology solution classes, allowing for prioritization of program technical activities and continuous analysis for significant or emerging safety trends. DFS will also support an X-37 intelligent vehicle health management (IVHM) flight experiment that will demonstrate the use of the Livingstone model-based health management system for real-time fault detection, isolation and recovery. During FY02, the initial drop test will be performed, demonstrating the full integration of the IVHM software into the Boeing flight software. This will be followed by the orbital flights which will further showcase the diagnostic capabilities provided by this technology.

In Intelligent Systems (IS), FY 2002 will also see the completion of major steps towards autonomous science exploration, including the development of the conceptual high-level autonomy architecture for planetary rovers. A collaboration has been formed with the Mars 2003 mission team to demonstrate the benefits of advanced planning and scheduling technology for automated sequence generation. The technology will be integrated into existing tools to be used by the mission and will be considered for incorporation into the mission following the demonstration. This effort is expected to demonstrate a speed-up of a factor of four in the total amount of time required to generate an initial sequence, thus allowing increased interaction between the science and engineering teams while also increasing the overall robustness of the sequence generation process. The IS element will also demonstrate and benchmark the current state-of-the-art for automated software verification and validation using Mars Pathfinder code. This activity will demonstrate the benefits of existing techniques while establishing benchmarks for future comparisons. One of the end objectives of this activity is to dramatically increase the overall level of software reliability for future Mars missions by facilitating the eventual adoption of these techniques. Finally, the benefits provided by a systematic analysis of the interactions within an integrated human-machine system will also be demonstrated as part of the Mars Exploration Rover 2003 Human-Centered Computing activity. Modeling and analysis techniques will be used to evaluate the performance of this system under various operational conditions and alternative mission operations strategies will be evaluated and compared in an effort to maximize the overall system robustness while enabling increased science return. In addition, it will establish a Research, Education, and Training Institute (RETI) in intelligent systems.

Another key CICT activity in human-machine systems and operations will be conducted within the Aerospace Operations Research (AOR) element. Specifically, countermeasures for flight crew fatigue will enter a new phase with the development of tools to assist aircraft operators in scheduling flight crews. An initial bio-mathematical model will be developed to predict crew behavioral performance based on sleep and circadian variables. New perceptual measurement tools for evaluating display effectiveness as they support human performance will be validated. This research is conducted using a combination of psychophysical studies, eye tracking, image processing, visual system modeling, auditory system modeling, virtual environment technologies, and evaluations of the interactions between perceptual factors, displays and controls.

In FY 2002, the Bio-Nanotechnology element of the CICT Program will develop methodologies for producing revolutionary aerospace structural materials by exploiting the interface between biotechnology and nanotechnology. Emphasis will be on the development of evolvable (self-assembling) self-repairing systems for computing strategies and spacecraft components. Emphasis will be placed on increasing production of single wall carbon nanotubes and on characterizing the first-order behavior properties of carbon nanotube materials. In nanoelectronics, efforts will continue on controlling the growth, alignment and chirality of nanotubes and developing concepts for nanoelectronic devices and the modeling of their properties. Work will also continue on nano- and quantum-sensors and instruments, including single molecule detection and discriminators. In addition, it will establish a Research, Education, and Training Institute (RETI) in biotechnology and nanotechnology computing.

Finally, a cornerstone in CICT strategy for accelerated technology infusion is the Aerospace Autonomous Operations (AAO) element. AAO provides prototyping and mission insertion support to carefully selected projects from the other elements of CICT. Project selection is based on a clear identification of mission need coupled with the high promise of delivering new or more effective mission capabilities with a specific focus on software that can perform mission decision-making independent of human control. Selected projects will develop technologies to readiness levels suitable for mission readiness and mission insertion. The benefit areas for AAO include planning and scheduling for aerospace applications, health management, executives and distributed intelligence, and sensors/reflexes for aerospace applications. AAO provides support for test beds, flight demonstrations and/or system studies to promote the effective and efficient transition of emerging technologies into missions. For example, advances in neural flight controls research will be applied to candidate aircraft and space transportation vehicle simulations and will demonstrate reduced cost and enhanced vehicle performance. Other specific areas of AAO support include (1) Development or refinement of test beds such as the Mission Data System (MDS) at JPL for mission software development for Mars and other deep space missions; (2) A High Dependability Software Test Bed for the rigorous testing of new approaches to software development, verification and validation; (3)

Demonstration of a neural net-based Intelligent Flight Controller (IFC) for resilient systems development within a transport class testbed; (4) Detailed system studies evaluating both the technical and financial risks/benefits of incorporating new technologies such as Integrated Vehicle Health Management (IVHM), automated planning and scheduling software, or high-end computing into NASA's future missions. Furthermore, research to advance adaptive control technologies applicable towards future space transportation vehicles will be conducted in FY02.

Intelligent Synthesis Environment

The program implementation strategy was to produce a sequence of ISE technology capability builds based on definition, development and test phases. As a result of reviewing ISE progress and information technology priorities, the ISE Program will terminate at the end of FY 2001. FY 01 activities have been focused on the 2nd Generation RLV application to ensure a smooth transition of technology between ISE and the 2nd Generation RLV program. As part of the orderly closeout in FY 2001, the first ISE capability build, a proof-of-concept system, will be validated. ISE Build 1 will include an integration of performance disciplines, cost and risk modeling and conceptual life-cycle design space definition for new design problem synthesis in the life-cycle simulation program element. The environment program element will incorporate team collaboration tools, intelligent network capability at five NASA centers, secure audio/video/data conferencing capability, distributed runtime core capability and services, prototype synthesis framework, voice command and control of desktop applications and a graphical user interface into ISE Build 1. In addition, two dedicated immersive facilities are now available to demonstrate ISE capabilities. The product integration element will integrate Enterprise-specified discipline tools, implement the Enterprise-specified environment and architecture services and user interface capabilities into ISE Build 1. The cultural infusion element will create the ISE technology assessment methodology and feedback mechanisms to update and improve ISE tools and processes validated in ISE Build 1.

Aerospace Vehicle System Technology

In FY 2000, the VST program began a deliberate shift in the focus of the program to maximize the synergism between aeronautics and space transportation. Many of the fundamental technologies have obvious applicability in both these critical areas. The program continues to develop technology in the areas of safety, environmental compatibility, general aviation, next- generation design tools, experimental aircraft and access to space. To enhance environmental compatibility, technologies were developed to reduce emissions and drag using smart devices with active components. High-payoff, innovative control concepts were developed and demonstrated. The Blended Wing Body wind-tunnel model tests and conceptual designs of two advanced- configuration aircraft were completed. The first flight test of the Hyper-X Research Vehicle (HXRV) was delayed until FY 2001. Manufacturing methods for a new generation of advanced general aviation aircraft; additional training modules in flight training curricula, multifunction display guidelines, a low-cost communications, navigation and surveillance system, and a highly integrated open architecture avionics system were completed. The VST program also developed flexible patch-on actuators applicable to actuation of a wide range of film-based and highly packageable space structures as well as to non-aerospace applications. This actuator technology was chosen as one of the best inventions of the year 2000 in the annual R&D 100 Awards competition, sponsored by Industrial Research Magazine. The actuator was applied to active vibration and position control of smart inflatable structure that will enable large optical systems and gossamer spacecraft. In another gossamer technology advancement, analysis tools were developed to predict the mechanical properties, dynamic behavior, and effects of imperfections on the performance of membrane-based structures, crucial to the development of efficient and reliable gossamer structural concepts. In other areas of VST, a preliminary design tool was developed and made public to predict the simple effects of spacecraft charging on satellites. And finally, an on-line knowledge base was developed containing material out-gassing information from the American Society of Testing and Materials (ASTM) 1559 and quartz-crystal microbalance (QCM) flight data. Also synthesized first carbon nanotube doped thin film. Doping of 0.1% increased electrical conductivity by 1000xwhich could prevent build-up of static charge if applied to future spacecraft.

In FY 2001, the VST program will continue to exploit synergies between to aeronautics and space transportation technologies. The program will continue to develop technology in the areas of safety, environmental compatibility, general aviation, next- generation design tools, and experimental aircraft. The program will also support access to space goals. Activities transferred from the Advanced Subsonic Technology Program will be completed including large-scale validation of noise reduction technologies as well as flight testing of the general aviation system concepts and publication of the general aviation standards and methods. Many important tasks will be completed in FY 2001 for space transportation including the first Mach 7 flight of the Hyper- X vehicle and identification of protocols and methodologies for accelerated testing of space transportation materials. A key workshop will be held in 2001 to assess the state of turbulence research and determine future research needs to accurately predict aerodynamic flow and noise generation. Also, tests will be completed to provide a benchmark to the National Transonic Facility for ground-to-flight scaling on a cruise wing configuration of a transport aircraft. The annual OAT goals assessment will be completed to understand progress toward Enterprise goals. Hingeless control surfaces will be evaluated in wind tunnel testing. Systems analysis will begin on personal air vehicle concepts to understand benefits of these vehicles to the small transportation system. Real-time piloted simulation validation will be completed to determine potential viability of a vehicle central nervous system. Free-form ultra-lightweight structural component fabrication will be demonstrated: the first-order material/structural properties of carbon-nanotube-based materials will be characterized, an important first step to enable simulation tools that accurately predicts performance. The design of prototype carbon nanotube electromagnetic field sensor that will use less power than current sensor technology will be completed. The program will develop a thin-film polymer actuator for shape control of membrane structures. Analysis tools for film-based and gossamer structures will be validated via testing of a variety of components. These tools require development of test and measurement techniques. Development of an expert tool that will provide efficient, rapid and highly reliable selection of space-capable materials that meet the requirements of specific engineering applications will be completed. The program will also complete a 3-year test program to determine electrical properties of a wide array of spacecraft materials and will integrate this new information into relevant NASA databases and models.

In FY 2002, the VST program is focused on development of revolutionary new technologies to improve the performance of air vehicles and space transportation vehicles. The successful development of these technologies will support the Aerospace Enterprise Goals and Objectives. Tasks for space transportation will be completed including the second flight of the Mach 7 Hyper-X vehicle and first flight at Mach 10 as well as demonstration of adhesives technology necessary for large structural components. The annual OAT goals assessment and system studies of several revolutionary concepts will be completed. The first demonstration of micro-oscillatory blowing to enable simplified high-lift systems will be completed. Maturation and validation of high payoff transport aircraft technologies with potential safety, emissions, and cost benefits through partnership with industry and other government agencies will be conducted. To increase structural efficiency of polymer matrix materials, candidate processes for fabricating aligned carbon nanotubes composites will be evaluated. Conductivity sorting of carbon nanotubes will be conducted for selection of the best nanotubes for electronic and optical device applications. Adhesives for non-autoclave composite processing will be demonstrated to provide the technology required for large-structural components. Also in FY 2002, a new vehicle research thrust will be undertaken to explore advanced vehicle concepts and revolutionary new technologies to enable the development of advanced 21st Century Air Vehicles. Advanced materials and structural concepts will be developed to fully exploit the weight reduction potential of nanophase materials. Embedded sensors will be developed to provide real-time health monitoring of the structure. Intelligent systems made of smart sensors, microprocessors, and adaptive control systems will enable vehicles to monitor their own performance, their environment, and their operators in order to avoid crashes, mishaps, and incidents. Smart sensors and actuators embedded in the structure will provide an effective central nervous system for stimulating the structure to create physical responses such as changing shape. Research will also be conducted to develop microactuators that can be used to control aerodynamic flow about the vehicle. Advanced analyses methodologies will be formulated to model and thus predict the optimum locations for flow control devices to minimize airframe noise, reduce fuel burn, and enhance safety by providing additional control authority. This research will result in revolutionary new vehicle designs that are safer and more efficient than today's aircraft. These new air vehicles will be safer, fly quieter, burn less fuel, and have vastly improved high lift systems to enable safe takeoff and landing from short airfields to enable more of this countries 5400 rural/regional airports to be used.

Emphasis will be placed on flight systems, navigation and control, and sensing technologies to enable multiple small spacecraft to share in science observations and measurements distributed over vast areas will be investigated. The development of advanced capabilities coupled with component technologies to reduce launch and on-orbit power requirements will augment this effort to enable affordable continuous distributed science data acquisition for earth and planetary atmospheres and surfaces and for in-space science objectives.

NASA is pursuing fundamental investigations in nanotube research and other related areas at nano-scale dimensions, one-millionth of a millimeter. These investigations are expected to lead to applications materials with properties tailored to provide extraordinary physical properties that can enable breakthrough capabilities in aerospace systems. Efforts will focus on the development of new materials chemistries with nano-particles to provide radiation shielding films and composites and on the development and evaluation of advanced material processing methods for ultra-lightweight systems that cannot support themselves in Earth gravity. To obtain the maximum structural efficiency for polymer matrix materials, aligned carbon nanotubes will be demonstrated. Conductivity sorting of carbon nanotubes will be undertaken for selection of the best nanotubes for electronic and optical device applications. A model for polymer crystallization/chain packing will be developed to enable tailoring of material properties and design of novel microstructures. The feasibility of carbon nanotube (CNT) sensors for human respiratory health monitoring will be demonstrated. CNTs will be sorted according to diameter and length using field effects. Sorting is important to enable the production of mono-disperse distributions of CNTs for various applications that require uniformity.

New micro-meteoroid models will be developed and integrated with other Space Environmental Effects software and a revolutionary new model of the electron environment for all altitudes and reflecting solar cycle variations will be created to replace current models that are 20-years old or more.

Finally, VST will establish a Research, Education, and Training Institutes (RETI) in vehicle systems technology research. To ensure the highest quality research and training and infusion of new ideas, these RETIs will be subject independent, external reviews and recompetition at regular intervals, including mandatory sunsets after ten years.

Propulsion and Power

The Propulsion and Power (P&P) program develops technology that supports all Enterprise goals and objectives. During FY 2000, the General Aviation Propulsion project continued development of two engines (one turbine and one diesel) that can provide revolutionary advances in performance and cost and help to revitalize the U.S. general aviation industry. The turbine engine development has already lead to the announcement of a new general aviation aircraft venture known as Eclipse Aviation. Work was completed on the development of 900°F silicon carbide pressure sensors, and the sensors have been transferred to industry for use. The Emerging Survivable Aircraft Technologies project continued active technology validation activities in coordination with DoD. Excellent progress was made in the development of critical air-breathing launch vehicle component technology. Engine safety improvement efforts also continued with emphasis on development of more crack-resistant alloys for blades and disks, and an improved containment system. Also, a new effort to establish the feasibility of pulse detonation-based technologies to hybrid-cycle and combined-cycle propulsion systems for meeting the aviation and access-to-space goals was initiated. A zero CO2 research project was also initiated. This project is focused on identifying the technologies needed to drastically reduce or eliminate CO2 emissions from civil transport aircraft.

The Aircraft Icing project made significant contributions to alleviation of aircraft icing hazards. A joint US and Canadian flight/ground experimental investigation to define performance of different ground sensing technologies in detecting atmospheric icing conditions was completed. With the Airline Pilots Association and the FAA, NASA developed and distributed an educational video on icing for increasing regional pilot awareness of icing hazards. Another major experimental investigation with the FAA regarding icing on modern airfoils was completed. It significantly advanced the state of the art in aircraft icing prediction tools by providing a broad base of information about ice accretions and the resulting effects on aerodynamic performance. Prior to this effort, the NACA four digit series airfoil sections created in the 1950’s served as the state of the art. The final report documents ice accretions formed over a wide range of aircraft icing conditions and resulting aerodynamic performance degradation for airfoils representative of three classes of aircraft: commercial transport, business jet, and general aviation.

During FY 2001, validation of rocket-based combined cycle (RBCC) propulsion inlet, mixer-combustor, and integrated propulsion pod component is planned. The effort to improve engine safety will continue to seek alloys for more crack-resistant blades and disks for delivery in FY 2001. P&P will continue to work on controlling combustion instability in engines, thus enabling lower emissions operations. Oil-free turbomachinery will be developed, with a complete core-section radial-foil bearing tested. Oil-free turbomachinery could lead to simpler, easier to maintain engines. In the area of pulse detonation engines, design concepts for hybrid and combined cycle propulsion systems will be developed. The fundamental aspects of noise generation and propagation and the identification of advanced noise reduction concepts will continue. This activity will provide enabling capabilities for new, high-risk, high-payoff technologies that are of long term strategic importance in noise reduction. An analysis of a liquid-hydrogen-optimized engine and airframe will be completed in support of the Zero CO_2 Research project. Hydrogen-fueled engines, as a substitute to hydrocarbon fuels, can curtail CO_2 emissions by reacting with the oxygen in the atmosphere to produce water but no

CO or CO_2 byproducts. The permeability of lightweight polymer-composite liquid-hydrogen tanks will be determined. Reduction of the hydrogen permeability of polymer matrix-composite tanks may allow the safe and efficient storage of low-density liquid hydrogen in commercial transport aircraft. New energy conversion technologies will also be investigated. The fracture toughness of solid oxide fuel cell electrolytes for high-pressure hydrogen/air fuel cells will be determined. New initiatives will include the Revolutionary Aeropropulsion Concepts project which has the goal of investigating systems that can produce up to 2 times the payload/range of current engine systems. Also, nanotechnology as applied to the harsh operating environments encountered in turbine engine systems will be investigated. Icing research will continue to be conducted across a broad range of fronts from modeling to database development to systems concepts to education outreach. During this year, the project's primary emphasis will be to review, evaluate and select candidate remote sensing technologies to serve as a prototype ground-based system to sense atmospheric icing conditions.

During FY 2002, efforts to improve engine safety will continue. The UltraSafe Propulsion project will develop new composite-containment system structural concepts that can be transferred to the Aviation Safety Program for full-scale validation. In order to reduce engine emissions, we will demonstrate revolutionary fuel injector concepts that utilize advanced technology, including ceramics, MEMS, and active combustion control to reduce NOx emissions by 80% and to further reduce particulate and aerosol emissions. Oil-free turbomachinery will be further developed, with testing of an oil-free core on a general aviation engine, wherein the shaft will be fully supported by an air bearing. The Zero CO_2 project will complete an assessment of hybrid fuel cells and liquid hydrogen optimized turbofan concepts, pointing the way toward feasible concepts for further development for reducing or eliminating CO_2 emissions. Pulse detonation engine technologies will be further matured, with the demonstration of critical sub-system performance in one or more PDE system concepts. The Revolutionary Aeropropulsion Concepts project will complete identification and preliminary performance assessment on possible future configurations for advanced aeropropulsion systems. This will result in an update of the portfolio for enabling technologies for extremely high-payoff future propulsion systems. In addition, the Propulsion and Power Program will focus on technologies applicable to engine designs for 2nd and 3rd generation reusable launch vehicles. These RLV technologies, aimed at enabling high performance, long life and high thrust to weight include air breathing combined cycle engines, advanced materials and structures and propellants, improved test instrumentation and new analysis/design tools. The activities will include both turbine-based and rocket-based combined-cycle propulsion concepts. Other novel propulsion concepts will also be addressed. The aircraft icing research will progress towards outyear milestones related to modeling, smart-icing systems and ground-based sensing of atmospheric icing conditions. In addition, it will establish two Research, Education, and Training Institutes (RETIs) in propulsion and power research. . To ensure the highest quality research and training and infusion of new ideas, these RETIs will be subject independent, external reviews and recompetition at regular intervals, including mandatory sunsets after ten years.

Flight Research

The Flight Research Base R&T Program continued, during Fiscal year 2000, to safely conduct, enable, and improve NASA's atmospheric flight research capability. Research activities were conducted in the Environmental Research Aircraft and Sensor Technology (ERAST) project with the initial low-altitude flights of the Helios aircraft, which has a 247-foot wingspan and an ultimate altitude goal of 100,000-feet. Preparations are underway to ship the Helios flight and ground support equipment for the summer 2001 deployment where flight to 100,000 feet altitude will be demonstrated. Full deployment will be completed in April 2001. Low-altitude flights are expected to begin late May 2001. The Helios aircraft has commercial market potential as a communications relay platform and Dryden has prepared an implementation approach to Helios technology commercialization for the NASA technology/commercialization office. As a highlight of ERAST FY 2000 flight activities, Dryden completed a GPRA milestone of demonstrating over-the-horizon control of a remotely piloted aircraft outside of controlled airspace using commercial satellite networks. This milestone validated a technology to meet the Earth Science Enterprise requirements for research aircraft to conduct in-situ atmospheric data collection. Also within the ERAST project, the Predator B successfully completed its initial flights in early February 2001. This is a significant achievement towards completing the September 2002 milestone of flight -demonstrating RPA capability to conduct science missions.

The Revolutionary Concepts (RevCon) project began in 1999 with a modified 'Quick Start' approach, and selected for a FY 2000 start the Blended Wing Body, Aerocraft (partially buoyant airship), and Pulse Detonated Engine projects. Both the Blended Wing Body, and Aerocraft projects were later dropped for lack of ability to meet scheduling. The Autonomous Formation Flight activity was instituted as a substitute project. The next generation of RevCon research activity was selected in August 2000 from a broad research solicitation. These projects, currently completing their Phase I evaluation, cover the spectrum of flight research activities. RevCon Phase-1 selections include revolutionary vehicle designs (Joined Wing, Smart Vehicle-Advance Technology Demonstrator), control technology (Reliable Autonomous Control Technology), rotorcraft (Swashplateless Flight, Variable Diameter Tilt Rotor), propulsion (Advanced Supersonic Propulsion and Integration Research, Reliable Propulsion for Aeronautical Vehicles, Shaped Memory Alloy-Variable Area Nozzle), and extreme aeronautical conditions (Apex) high-altitude, sub-sonic test vehicle.

The Flight Research Program also provided autonomous taxi control software to the X-45 program and continued its testbed research activities in FY 2000. The X-45 aircraft was received at Dryden mid-November 2000. Complete aircraft system evaluation and ground vibration tests were initiated in preparation to meet the 2001 milestone.

Fiscal Year 2001 promises to be a productive year of flight research in the Flight Research Base R&T Program. In ERAST, the Flight Research program will demonstrate a solar-powered RPA at 100,000 ft. Also, toward completing the FY 2003 milestone of sustainable flight over 96 continuous hours, ERAST will finish development of a prototype energy storage system. Both achievements will demonstrate technologies that will enable atmospheric satellites for commercial use and enable the Nation to undertake scientific subsonic sampling high in the stratosphere. Changes in the RevCon project due to policy, program, and budgetary decisions will necessitate a reduction in ongoing activities and a restructuring of the approach and execution of the project. The Autonomous Formation Flight project will maintain commitments to initiate flight test to validate control algorithms. The remainder of the program will be reviewed, and restructured, with the resulting program presented to our stakeholders as soon as possible.

In pursuit of efficiency and affordability, in the Advanced Systems Concepts project will continue modification and systems checkout of an F-18 testbed aircraft in preparation for FY 2003 flights to investigate Active Aeroelastic Wing (AAW) technology and the X-45 will validate its autonomous taxi algorithms. Flight testbed activities this year may include: DFRC aerostructures test wing, flight evaluation of the propulsion flight test fixture, airborne Schlieren imaging system, supersonic natural laminar flow phase II, and laminar flow experiment.

Research activities for FY 2002 will be driven by the re-scoping of RevCon, reviewing ERAST plans against additional endurance goals, and other innovative flight research experiments. Continuing from the 'QuickStart' RevCon, the Autonomous Formation Flight project will demonstrate the benefits of formation-flight in drag-reduction. Other flight research on testbed aircraft, in FY 2002, may include innovative research in: Continuous Moldline Technology, Propulsion Flight Test Fixture with a test article, the UCLA Lobed Injector Experiment, Laminar Flow Experiment #3, and preliminary Pulse Detonation Engine testing.

ERAST will continue with the development and demonstration of a turbo-prop UAV for routine flight operations in the National Airspace System with capabilities that exceed the minimum Earth Science Enterprise altitude and duration requirements. Flight testbed activities in FY 2002 year may include: Continuous Moldline Technology, Propulsion Flight Test Fixture with a test article, the UCLA Lobed Injector Experiment, Laminar Flow Experiment #3, and preliminary Pulse Detonation Engine testing.

Rotorcraft

In FY 2000, the Rotorcraft program continued to provide new technologies for improved safety, reduced noise and vibration, rapid & economical design methods, and transferred them to the U.S. rotorcraft. Noteworthy accomplishment in Rotorcraft included:

- In the area of rotor aeromechanics and acoustics, rotary wing systems were improved to increase efficiency, while reducing vibration and noise, through innovative application of active controls. Improvements were demonstrated through wind tunnel tests. A new capability was developed and calibrated for large-scale wind tunnel testing of rotary wing systems up to 50,000-lb thrust and 6000 HP. A number of innovative active and passive noise and vibration reduction concepts were identified and selected for further research. These include the Active Twist Rotor, the Low-noise Platform Rotor, and the Modulated Rotor Design. Active noise controls were flight demonstrated to reduce cabin interior noise by up to 23 dB for selected gear mesh frequencies that are the main source of noise. The computer prediction model TRAC (Tilt-rotor Acoustics Code) was validated using data from flight tests with a MD 900 helicopter. The model is accurate within several decibels and can be used to predict the noise on the ground for a wide variety of flight-path descents. TRAC can be used to optimize approach and landing paths to produce minimum-noise footprints.

- In the area of Composite Structures for rotorcraft, improved methods for fatigue life prediction were developed and applied to design of flex beams for tail rotor systems.

- Moreover, the program developed technology for improved safety. Health and usage monitoring systems and predictive technologies were developed and evaluated. A proof-of-concept demonstration was completed for the world's first ultra-safe gear. Methods of predicting and measuring pilot situation awareness were developed and tested to allow designers the take this key factor into account when designing new systems. Using the situation awareness prediction model, the effectiveness of new displays and other pilot interface technologies for improving pilot situation awareness were studied and specifications for hardware and format of cockpit displays defined to improve pilot situation awareness. A new website for rotorcraft safety was established.

- Project NRTC has developed and transferred technology to industry to improve the performance, utility, and public acceptance of both helicopter and tilt-rotor concepts. The developed technology will 1) improve flight-safety through the use of health-management systems and crash-proof designs, 2) enhance design and manufacture through the use of integrated design and manufacturing tools, and 3) alleviate both interior and exterior noise through active control technologies and optimized flight paths near communities.

After consideration of research priorities within Aerospace Technology budget constraints to relieve air system, the Rotorcraft Program will be terminated at the end of FY 2001. As part of the orderly closeout of program activities, the FY 2001 funds will be prioritized to provide the following accomplishments. An Ultra-Safe Gear Design Guide will be published, completing the provision of ultra-safe gear technology, which was first demonstrated in FY 2000 through testing and correlation with design tools. In the area of Composite Structures Technology for Rotorcraft, a certification methodology will be delivered for inclusion in Mil-Std Handbook 17. Also, a new physics-based design tool for composite structures will be provided for prediction of stringer/skin separation mode of failure. Flight tests will be completed that demonstrate and validate control laws for low pilot workload under typical civil operations involving low-visibility weather conditions. There will be advances made in the areas of crashworthiness of rotorcraft that will demonstrate mitigation of damage to airframe structures due to crash/harsh landings onto both soft and hard surfaces such as soil, concrete, or water. To improve flight safety and lessen the cost of maintenance, new HUMS (Health and Usage Monitoring Systems) protocols will be developed. HUMS will track wear and tear on critical parts as well as sense deterioration and give warnings. Plans for limited flight evaluations of HUMS acceptable to both DoD and FAA will be developed. In the area of design tools for rapid prototyping, there will be a demonstration conducted for the new "express- tool" technology. This can reduce design to fabrication time by 50% where it is applied to complicated parts and assemblies.

Space Transfer and Launch Technology

Space Transfer and Launch Technology (STLT) is executed by the Advanced Space Transportation Program Office (ASTP) at NASA MSFC. The STLT Program is the technology base program for space transportation. Future revolutionary advances in space transportation technology will be developed in this program to reduce costs and increase reliability and performance across the entire mission spectrum. Advanced technologies will be developed and ground-tested to bring them to readiness levels where they can either be adopted by industry, or if necessary, flight-proven. The STLT Program will focus on technological advances with the potential to increase the safety/reliability while reducing launch costs beyond the 2nd Generation RLV Program. In addition, it will make key technology investments for in-space transportation systems to reduce costs, system mass and trip time for future in-space missions with a primary emphasis on enabling new robotic missions.

The STLT consists of four investment areas:

- 2nd Generation Reusable Launch Vehicle (RLV) – Development of technologies required by a 2nd Generation RLV. Currently includes the RLV Focused Project. Requirements and funding for this project are provided by the 2nd Generation RLV Program.

- In-Space – Development of technologies for robotic missions such as solar system exploration, Earth-Sun connection, Mars exploration, low cost earth orbital transfer and earth observation. In-Space projects are largely guided by the needs the Space

Science Enterprise. These projects support OAT Goal 2 and 3, Objectives 7, 8 and 10.

- 3rd Generation - Development of technologies which advance the state-of-the-art in propulsion, airframe and launch vehicle systems, operations and integrated vehicle health management. Spaceliner technology priorities are derived from the contribution to transportation system safety and cost goals and are envisioned to support future Department of Defense, commercial and civil space transportation needs. These projects support the long-term elements of OAT Goal 2, Objectives 6 and 7.

- Space Transportation Research – Research of very advanced, breakthrough concepts for revolutionizing space travel. These projects support OAT Goal 3, Objective 10.

In FY2000, the STLT completed several technology demonstrations, including: fabrication of an Advanced Ceramic Matrix and Metal Matrix Composite thrust cell chamber; completion of over 2000 two-dimensional unsteady Computational Fluid Dynamics (CFD) runs for optimization of turbine performance which showed a gain of 10 points of efficiency at design conditions over standard design practices; development of an Automated Tape Placement Device with attached E-Beam Gun for ply-by-ply, cure on the fly fabrication capabilities of E-Beam curable resins; completion of a 500-hour test of a 10kW Hall Electric Thruster; completion of ProSEDS hardware fit check on the Delta upperstage; fabrication and test up to 150 psi of two polymer matrix composite liquid hydrogen ducts; accumulation of over 1 hour of test time on the Rocketdyne Rocket Based Combined Cycle (RBCC) A-5 engine ; assembly and initial testing of a liquid oxygen densification unit; successful hot-fire of the TRW Ultra-Low Cost Engine (Pintle); completion of a comprehensive planning process for FY2001 and out activities consistent with the Integrated Space Transportation Plan (ISTP); establishment of the Space Transportation Information Network (STIN) for managing and disseminating technology development data, on the internet; establishment of over 20 standing Technology Working Groups (NASA, DoD, DoE, industry and academia); and creation of the Integrated Technology Assessment Center (ITAC) to aid ASTP in prioritizing technology investments based on sound systems analysis.

FY2001 activities will be consistent with the Integrated Space Transportation Plan and guided by comprehensive systems analysis. 2nd Generation RLV technology investments will include composite aerospike ramps, composite lines and ducts, long life, lightweight thrust cells, advanced combustion devices, large-scale testing of hydrogen propellant densification and development of the integrated powerhead demonstrator. In-space activities include cryogenic fluid management, electrodynamic tethers, electric propulsion, solar sails and aeroassist technology development. In addition, significant planning efforts for in-space activities will be conducted with the Space Science, Earth Science and Human Exploration and Development of Space Enterprises. The focus of 3rd Generation activities will be on revolutionary propulsion and airframe technologies. In propulsion, work will begin with the RBCC engine consortium to conceptually define and conduct select future component and subsystem ground and flight test demonstrations of a flight-weight RBCC engine systems. Crosscutting technologies will be pursued which support both rocket and air breathing concepts, such as long life turbomachinery, revolutionary materials, and numerical simulation of propulsion systems and smart sensors. Other 3rd Generation investment areas include: development of rapid design and analysis tools; flow control through plasma aerodynamics; morphing structures; SHARP ultra-high temperature ceramic materials; integrated smart/adaptive thermal-structures and intelligent thermal protection systems; structurally integrated, wireless, micro/nano sensors and avionics; regenerative sensors; autonomous/adaptive control; and technologies for spaceport /range operations. In addition, advanced research activities will continue to be guided by concepts that have the potential for enabling future generations of RLV's and interstellar travel.

FY2002 activities will continue work initiated in FY01. STLT will continue to develop improved systems analysis capabilities to ensure that STLT investments are addressing high- priority needs and are making progress towards the Enterprise and program goals. STLT will continue to increase university participation in long-term research and technology. 3rd Generation activities will be tied closely with the future needs of the United States Airforce as defined by the National Hypersonic Propulsion Plan. Propulsion activities will be centered around completing the systems requirements review for the 1st flight-weight rocket-based combined cycle engine system and completing key component and subsystems level propulsion and airframe demonstrations. In addition, STLT will develop the technologies required for a Mach 4 revolutionary turbine-accelerator propulsion system and a hydrocarbon ram/ scramjet. In-Space Transportation activities will be funded and managed in the Space Sciences Enterprise beginning in FY 2002.

Special Interest Programs

In FY 2000 and 2001, this funding area covered a variety of high-visibility projects and tasks that are of special interest for Headquarters attention including Congressional mandates, inter-agency and inter-governmental partnerships, jointly funded university/industry agreements, flight experiments, and exploratory technology initiatives. To concentrate Enterprise activities on high priority, high performance programs within Aerospace Technology budget constraints, these efforts will be terminated at the end of FY 2001

FY 2001 funds will be used for the orderly closeout of the following activities:

- The development of AirSEDS tethered satellite mission
- The Ultra-Low Power (ULP) program will focus on developing the technologies required to enable missions to use ULP electronics including integral bias circuits and level translation technology. Work will include optimizing the cell library to double the onset threshold for Single-Event-Upsets (SEU's). Additionally, new circuit types will be designed using ULP demonstrating the wide applicability of this technology. This will be the last year of funding for this program
- The Commercial Space Centers at Auburn, Texas A&M, Maryland and Florida Atlantic Universities
- The Polymer Energy Rechargeable System (PERS) project and Glennan Initiative

The FY 2001 Congressional Budget provided an augmentation to the Space Base budget for Nanotechnology ($5 million) in addition to the already on-going Rice University study of improved methods for producing carbon nanotube materials. NASA is pursuing fundamental investigations in quantum effects, atom imaging and manipulation, nanotube research, and other related areas at the nano-scale of dimensions, one-millionth of a millimeter. These investigations are expected to lead to applications such as lighter, smaller, and more capable spacecraft; biomedical sensors and medical devices; powerful, small, low-power computers; radiation-hard electronics; and materials with properties tailored to provide extraordinary physical properties.

The NASA funding of the National Robotics Engineering Consortium will be completed as planned in the original 5-year agreement. The consortium is expected to continue under funding from commercial customers it has developed successfully under the NASA partnership. Final year activities include the completion of 10 new patent applications.

NASA Research Announcements (NRA's):

The Aerospace Base Technology program uses open competition solicitations to broadly compete a significant portion of the program to ensure that the best ideas from all sources are made available for NASA missions.

In FY 2001, seeking high-payoff technologies that can revolutionize future space-flight systems, NASA announced the selection of 111 proposals totaling over $120 million over three years as a part of its Cross-Enterprise Technology Development (CETD) NRA, released in FY 2000. Over the next two-to-three years, principal investigators in 30 states, chosen from a field of more than 1200 offers, will explore promising new ideas that have potential for enabling the achievement of many of the Agency's long-range goals in space science, Earth science, and human exploration of space.

The broad range of studies sponsored under the CETD NRA and to be conducted by universities, industry, and private and government laboratories will address ten general technology areas. New sensors will be developed for the gathering of previously unavailable science data from remote sources. The automation of spacecraft functions will be studied to enable complex new missions with greatly reduced human intervention. New component technologies including advanced materials, micro-devices and support systems will be developed that could significantly reduce the mass, cost, and on-board resource needs of future spacecraft. The funds requested in FY 2002 will continue the funding of these multi-year proposals. The next CETD NRA competition is planned for FY 2004.

BASIS OF FY 2002 FUNDING REQUIREMENT

AEROSPACE TECHNOLOGY INVESTMENTS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Educational Program	---	2,000	-----
Minority University Research and Education Program......................	(7,200)	9,200	
Total..	-----	11,200	-----

The Aerospace Technology Strategic Enterprise investments in higher education institutions include Federally mandated outreach to the Nation's Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), including Hispanic-Serving Institution and Tribal Colleges and Universities. This outreach is achieved through a comprehensive and complementary array of strategies developed in collaboration with the Office of Equal Opportunity Programs. These strategies are designed to create a broad-based, competitive aerospace research capability within Minority Institutions (MI's). This capability fosters new aerospace science and technology concepts by integrating Aerospace Technology Enterprise-related cutting-edge science and technology concepts, practices, and teaching strategies into MI's academic, scientific and technology infrastructure. As result, increasing the production of more competitive trained U.S. students underrepresented in NASA-related fields who, because of their research training and exposure to cutting-edge technologies, are better prepared to enter graduate programs or the workplace. Other initiatives are focused on enhancing diversity in the Aerospace Technology Strategic Enterprise's programs and activities. This includes exposing faculty and students from HBCUs and OMUs, and students from under-served schools, with significant enrollments of minority students, to the Enterprise's research efforts and outcomes, educational programs, and activities. To support the accomplishment of the Enterprise's mission, these programs are implemented through NASA Centers and JPL. The Centers and JPL support the MUREP through use of their unique facilities, program management and grant administration, and commitment of their personnel to provide technical assistance and assist in other facets of program implementation. Extensive detail as to how this funding is utilized is located under the MUREP portion of the budget. In FY 2002 this section will be transferred to the NASA respective program office.

BASIS OF FY 2002 FUNDING REQUIREMENT

FUNDAMENTAL SPACE BASE PROGRAM

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Fundamental Space Base	-----	98,184	-----
Total...	-----	98,184	-----

NASA has combined the Fundamental Space Base program and the Space Base NASA Research Announcements effort with the Aerospace Base beginning in FY 2001. This combination integrates the management of the programs, thus enhancing efficiency, as well as fostering synergy with the Aerospace Base.

BASIS OF FY 2002 FUNDING REQUIREMENT

AEROSPACE BASE NASA RESEARCH ANNOUNCEMENT (NRA) PROGRAM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Aerospace Base NASA Research Announcement (NRA's)	-----	39,912	-----
Total..	-----	39,912	-----

NASA has combined the Fundamental Space Base program and the Space Base NASA Research Announcements effort with the Aerospace Base beginning in FY 2001. This combination integrates the management of the programs, thus enhancing efficiency, as well as fostering synergy with the Aerospace Base.

BASIS OF FY 2002 FUNDING REQUIREMENT

AEROSPACE FOCUSED PROGRAMS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
High-Performance Computing and Communications	24,200	22,151	-----
Aviation System Capacity	62,929	68,449	100,600
Aviation Safety	64,394	70,844	70,000
Ultra Efficient Engine Technology	68,306	47,894	40,000
Small Air Transport System	-----	8,980	15,000
Quiet Airplane Technology Program	18,300	19,956	20,000
2nd Generation RLV	-----	271,501	475,000
X-33	84,600	-----	-----
X-34	64,300	17,861	-----
Future –X / Pathfinder *	34,500	-----	-----
Total	421,529	527,636	720,600

* Future X / Pathfinder program remains unchanged and is only reflecting a realignment in FY 2001 to the 2nd Generation RLV Program.

NASA's Aerospace focused programs address national needs, clearly defined customer requirements and deliverables, critical program decision and completion dates, and a specified class of research with potential application. Each of the focused programs is discussed in detail on the following pages.

BASIS OF FY 2002 FUNDING REQUIREMENT

HIGH PERFORMANCE COMPUTING AND COMMUNICATIONS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
High-performance computing and communications	24,200	22,151	-----

PROGRAM GOALS

The main objective of the Federal HPCC R&D programs has been to extend U.S. technological leadership in high-performance computing and computer communications. As this has been accomplished, these technologies were widely disseminated to accelerate the pace of innovation and improve national economic competitiveness, national security, education, health care, and the global environment. NASA's HPCC Program has been a key contributor to four of the five, current federal program component areas:

- High-End Computing and Computation
- Large Scale Networking, including the Next Generation Internet
- Human Centered Systems
- Education, Training, and Human Resources

NASA's primary contribution to the Federal program has been its leadership in the development of algorithms and software for high-end computing and communication systems which will increase system effectiveness and reliability, as well as support the deployment of high-performance, interoperable, and portable computational tools. As HPCC technologies have been developed, NASA has been using them to address aerospace transportation systems, Earth sciences, and space sciences research challenges. NASA's specific research challenges include improving the design and operation of advanced aerospace transportation systems, increasing scientists' abilities to model the Earth's climate and predict global environmental trends, further our understanding of our cosmic origins and destiny, and improving the capabilities of advanced spacecraft to explore the Earth and solar system. The HPCC Program has supported research, development, and prototyping of technology and tools for education, with a focus on making NASA's data and knowledge accessible to America's students.

In support of these objectives, the NASA HPCC Program has developed, demonstrated, and prototyped advanced technology concepts and methodologies, provided validated tools and techniques, and responded quickly to critical national issues. As technologies have matured, the NASA HPCC Program has facilitated the infusion of key technologies into NASA missions activities, the national engineering, science and education communities, and the American public. The Program is conducted in cooperation with other U.S. Government programs, U.S. industry, and the academic community.

STRATEGY FOR ACHIEVING GOALS

1) Infuse HPCCP technologies in to mission-critical stakeholder Enterprise/Office processes, and document discernable improvements in the stakeholders' processes and, if possible, final products as a result of the use of HPCCP technologies.
2) Increase the computer and communication performance available for use in meeting NASA mission requirements.
3) Increase the interoperability of application and system software operating on high-performance computing and communications systems available for use in meeting NASA mission requirements
4) Improve the portability of application software and data to new or reconfigured high-performance computing and communications systems available for use in meeting NASA mission requirements.
5) Improve the reliability of user-requested events executing on high-performance computing and communication systems available for use in meeting NASA mission requirements.
6) Improve the ability to manage heterogeneous and distributed high-performance computing, storage, and networking resources available for use in meeting NASA mission requirements.
7) Improve the usability of high-performance computing and communications tools and techniques available for use in meeting NASA mission requirements.

HPCC has pursued technologies at various levels of maturity. Applications in the areas of Earth science, space science, aerospace technology, and education have been used as drivers of HPCC's computational and communication technology research, providing the requirement context for the work done.

As a crosscutting multi-enterprise initiative, the HPCC Program has received funds from the Aerospace Technology (AT), Space Science (SS), and Earth Science (ES) Enterprises, and the Office of Human Resources and Education. In 2000, NASA concluded the process of refreshing the HPCC Program. The purpose of the "program refresh" was to better reflect each Enterprise's strategic plans in the HPCC Program. The "program refresh" also served to reinforce the crosscutting Enterprise needs across the projects in the areas of testbeds, system software, and applications.

The HPCC Program has been coordinated through the Aerospace Technology Enterprise and is managed by NASA Ames Research Center. The Program has supporting work at nine other NASA field centers and the Jet Propulsion Laboratory (JPL) and has been organized into five Projects:

- Computational Aerospace Sciences (CAS)
- Earth & Space Sciences (ESS)
- Remote Exploration and Experimentation (REE)

- Learning Technologies (LT)
- NASA Research and Education Network (NREN)

	FY 2000	FY 2001	FY 2002
Aerospace technology	24,200	22,151	-----
Earth Science	21,900	21,700	21,800
Space Science	14,600	24,900	-----
Education Programs	4,000	4,000	4,000
Total direct HPCC (NASA-wide)	64,700	72,751	47,600

The following discussion describes the projects managed by the Office of Aerospace Technology.

Computational Aerospace Sciences

The CAS Project facilitates the transfer of technology developed in NASA aerospace and information technology research efforts to routine use by operationally oriented or product-oriented programs within the NASA Aerospace Technology Enterprise. Work to date has provided the aerospace community with key tools necessary to reduce design-cycle times and increase fidelity in order to improve the safety, efficiency, and capability of future aerospace vehicles and systems. This has had the additional benefit of establishing within the aerospace community a viable market for vendors of high-performance computing hardware and software. CAS, because of this relationship with the general computer science community, has provided input and direction for developing technology for aerospace application.

The CAS Project has worked with NASA Aerospace Technology Enterprise Programs and the extended aerospace community to select high-priority areas that have bottlenecks or limits that could be addressed through the application of high-end computing. These challenging, customer-focused applications guide efforts on advancing aerospace algorithms and applications, system software, and computing machinery. These advances were then combined to demonstrate significant improvements in overall system performance and capability.

NASA Research and Education Network

The goal of the NASA Research and Education Network (NREN) Project has been to provide a next-generation network testbed that fuses new technologies into NASA mission applications. The capabilities realized by these new technologies will enable new methodologies for achieving NASA science goals. Moreover, these networking technologies will provide NASA missions with the advantages of enhanced data sharing, interactive collaboration, visualization and remote instrumentation. The goal of the NASA Research and Education Network (NREN) Project.

SCHEDULE AND OUTPUTS

Demonstrate 500 times end-to-end performance improvement of Grand Challenge and/or NASA mission applications based on FY 96 performance measurements across NASA NREN testbeds over 622 Mbps wide area network. Plan: March 2000 Actual: March 2000	Performed three demonstrations with 500 times more end-to-end performance improvement over FY 96 baseline.
Establish an international Next-Generation Internet eXchange (NGIX) Plan: January 2000 Actual: January 2000	Demonstrated connectivity across an international Next-Generation Internet eXchange.
Demonstrate multicast and quality of service (QoS) technology in a hybrid networking environment Plan: June 2000 Actual: June 2000	Provided at least two demonstrations of multicast and QoS technology in a hybrid (wireless and ground) networking environment.
Demonstrate time-to solution improvements for grand challenge applications on HPCC testbeds Plan: September 2000 Actual: September 2000	Demonstrate at least a 400-fold improvement over 1992 baseline in time-to-solution for one grand challenge application in the area of computational aerosciences. Accomplished using NPSS with an aircraft engine compressor simulation

Develop system software tools and techniques to enhance application performance Plan: June 2001	Software tools to reduce parallelization time from months to one week while maintaining 50% application performance compared with manual parallelization.
Develop tools and techniques to measure computing and communication capabilities Plan: September 2001	Tools to benchmark testbed performance in computing capability, database manipulation, and scheduling to evaluate alternate scheduling strategies and chose optimal approaches to reduce variability and improve predictability of turnaround time. Automated quality of service data collection tool for networks capable of measuring 2 service classes and scalable to at least 5 nodes.
Adapt application codes for high perfoance testbeds Plan: September 2001	3 relevant application codes parallelized and documented evaluation of parallelization tools. 3X performance in applications for aerospace through the integration of networking enhancements into application codes.
Demonstrate advanced networking tools and techniques on NASA mission-oriented applications Plan: September 2001	3 applications inter-operating on multiple QoS enabled networks; 50Mbps (aggregate internal) multicast; gigabit performance between 2 NASA sites; and 2 applications utilizing enhanced hybrid networking.
Research and Education Network (NREN) Project. Plan: September 2001	Technology advances achieved in the Research and Education Network (NREN) Project will be archived and documented for transfer as appropriate to other Aerospace Base R&T and Aerospace Focused programs.
Computational Aerospace Sciences (CAS) project. Plan: September 2001	Technology advances achieved in the Computational Aerospace Sciences (CAS) project will be archived and documented for transfer as appropriate to other Aerospace Base R&T and Aerospace Focused programs.

ACCOMPLISHMENTS AND PLANS

In FY 2000, HPCC CAS demonstrated improved time-to-solution for aerospace applications, as well as implementing the initial system software required for the creation and use of a distributed high-performance testbed (computational grid). With the successful installation, testing, and operations of a first-of-a-kind, 512 processor single-image SGI ORIGINS system, the CAS computational grid testbed provided the vital computing resources that demonstrated over 300 GFLOPS on benchmarking codes (more than 1,000-fold improvements over previously established baselines). Along with the dramatic improvements in computational capabilities, the HPCC NREN Project demonstrated key applications that required high- performance network capabilities, in some cases in partnership with CAS. In FY 2000, the NREN Project focused on the development and testing of mechanisms for scheduling guaranteed network quality of service to meet real-time bandwidth, latency and error tolerance requirements. This vital work supported the Federal Next Generation Internet (NGI) efforts, increased the quality, security and certainty of Internet transmissions, and demonstrated these improvements on a network capable of 1,000 times the capacity of established baselines.

After consideration of research priorities within Aerospace Technology budget constraints, the CAS and NREN projects will be terminated at the end of FY 2001. As part of the orderly closeout of these projects, CAS will build upon the successes demonstrated in benchmarking codes and work towards dramatic improvements over FY 1992 baselines in time-to-solution for relevant aerospace applications on high performance computing testbeds. These performance improvements will be partially supported through the development and demonstration of new software tools to measure testbed computing performance, database manipulation, and resources scheduling. These tools are needed in order to evaluate alternate scheduling strategies and choose optimal approaches to reduce the variability and improve the predictability of supercomputing resources. In addition, CAS will complete the development of software tools to dramatically reduce the time required to adapt applications to parallel high-performance systems. Specifically, CAS will develop tools to automatically reduce code parallelization time (from months to one week) while maintaining at least 50% of the applications performance when compared with manual parallelization. During this same time period, NREN will be providing the capability to monitor and measure performance of high-end networks, tools to enhance applications performance through the integration of networking enhancement into applications codes, and demonstrations of interoperation among high performance NASA and NGI networks.

BASIS OF FY 2002 FUNDING REQUIREMENT

AVIATION SYSTEMS CAPACITY

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Aviation Systems Capacity..................... ..	62,929	68,449	100,600

PROGRAM GOALS

The FAA "Aerospace Forecasts 2000-2011" report predicts that U.S. scheduled domestic enplanements will increase 55% over the next 12 years and that total international passenger traffic between the U.S. and the rest of the world will increase by 91%. This rate is higher than the population and economic growth rates. Also, according to airline representatives, delays in the Air Traffic Control System cost U. S. operators approximately $3.5 billion per year in excess fuel burned and additional operational costs, which are ultimately passed on to the consumer. Flight delays continue to escalate. The number of delayed flights in the National Airspace System has more than doubled in just the last 6 years. Due to environmental issues and cost, only one major new U. S. airport – in Denver – was opened this past decade. With little ability to build new or expand current airports in the populated areas where they are needed, the capacity of the nation's air transportation system will not meet consumer demand, airport delays will continue to accelerate, and the nation's economy and mobility will be adversely impacted.

To meet these growing capacity demands, more efficient and flexible routing, scheduling, and sequencing of aircraft in all weather conditions are critically needed. The U. S. aviation industry is investing $6 billion over 20 years to increase airport capacity. However, a gap still exists between the demanded capacity and the ability of the National Airspace System to handle the increased air traffic. Another part of the solution to capacity demands is to off-load the runways at major airports by developing simultaneous independent operations for short-haul civil tiltrotor aircraft. Studies conducted by Boeing Commercial Aircraft for NASA and the FAA and by various state and local transportation authorities (e.g., Port of New York and New Jersey Authority) have shown civil tiltrotor to be a viable candidate for relief of air traffic congestion.

The ASC program supports the Enterprise's objective of "while maintaining safety, double the aviation system throughput in all weather conditions within10 years and triple within 25 years". The goal of the Aviation System Capacity (ASC) program is to enable safe increases in the capacity of major US and international airports through both modernization and improvements in the Air Traffic Management System and the introduction of new vehicle classes which can potentially reduce congestion. Specifically: to increase National Airspace System (NAS) throughput while assuring no degradation to safety or the environment; to increase the flexibility and efficiency of operations within the NAS for all users of aircraft, airports and airspace; and to reduce system inefficiencies.

STRATEGY FOR ACHIEVING GOALS

The ASC program is composed of the Terminal Area Productivity (TAP), Advanced Air Transportation Technologies (AATT), the Virtual Airspace Modeling (VAM), and the Short Haul Civil Tiltrotor (SHCT) projects. The TAP project, which was completed in FY 2000, developed revolutionary technology and procedures to enable safe clear-weather airport capacity in instrument weather conditions. The AATT project develops decision-making technologies and procedures to enable substantial increases in the throughput, predictability, flexibility and efficiency of the national air transportation system in the context of the FAA commitment to “Free Flight”. The SHCT project develops technologies and procedures to overcome the most critical inhibitors to a civil tiltrotor operating within an improving and modernized air traffic system. The VAM Project will develop revolutionary new operational concepts for the aviation system beyond “Free Flight” and the capability to validate these concepts and their benefits in high fidelity simulation and modeling. The ASC program works closely with manufacturers, the airlines, the FAA, and the technology customers who collectively will identify operational requirements and will apply candidate technologies as operational systems.

In the area of Air Traffic Management R&D, NASA and the FAA have an integrated research and technology development plan, approved by both the NASA Associate Administrator for Aerospace Technology and the FAA Associate Administrator for Research and Acquisition. An Inter-Agency Integrated Product Team (IAIPT) is responsible for the strategic management of this area of research by the FAA and NASA, assuring that the efforts of both agencies are conducted to maximize the benefits of the research. The IAIPT reports to a NASA/FAA Executive Council, comprised of the appropriate Associate Administrators from both Agencies. Each agency is responsible for the conduct of its Programs. Oversight of the NASA Programs is provided through the NASA Advisory Council. The Ames Research Center is the lead center for the program and each of the three current projects, with the Langley and Glenn Research Centers providing supporting research.

The Terminal Area Productivity (TAP) project, which was successfully completed in FY 2000, focused on increasing capacity at airports under instrument meteorological conditions. The objective was to provide technologies and operating procedures to enable productivity of the airport terminal area in instrument-weather conditions to safely match that in clear-weather or visual conditions. The specific objectives included: (1) increasing current non-visual operations for single runway throughput by 15%; (2) reducing lateral spacing requirements for independent operation on parallel runways below 3400 feet; and (3) demonstrating instrument-weather runway occupancy time equivalent to that in clear weather. The TAP project developed and demonstrated: (1) airborne and ground technology and procedures that will enable safe reduction in aircraft spacing in the terminal area; (2) enhanced air traffic management (ATM) and reduced controller workload; (3) improved low-visibility landing and surface operations; and (4) integrated aircraft and air traffic systems to address the problems described above.

The goal of the Advanced Air Transportation Technologies (AATT) project is to develop technologies to enable the next generation of increases in capacity, flexibility and efficiency, while maintaining safety and not degrading the environment, of aircraft operations within the U. S. and global aviation system. In alignment with the national consensus for the operating paradigm of the future, called “free flight”, the technical approach is to provide human-centered, error-tolerant automation to assist in short- and intermediate-term decision-making among pilots, controllers and dispatchers to integrate block-to-block planning services. This will allow all airspace users to choose the best flight path for their own purposes within the constraints of safety and the needs of other users. Specific objectives include: (1) enabling “free flight” to the maximum possible degree to allow users to maximize business/customer impacts by making trade-offs between time and routing; (2) improving the effectiveness of high-density operations in regions on the ground and in the air where free flight will not be possible, and (3) enabling operation in a smooth and efficient manner across boundaries of free flight and capacity-constrained flight regions.

The goal of the new Virtual Airspace Modeling Project is to provide by 2007 the foundations for setting the direction for the future air traffic management system beyond "Free Flight". This project enables NASA to initiate the first steps toward fulfilling the 25-year strategic goal to " triple the capacity of the aviation system within 25 years, based on 1997 levels". The Virtual Airspace Modeling Project will establish a virtual airspace simulation environment with a never-before-achieved level of fidelity for the real-time test and validation of new and innovative solutions to the nation's aviation system problems. This capability will be key to evaluating revolutionary air traffic management operational and technological that could dramatically reduce airport congestion and delays while maintaining or increasing air system safety.

While the tiltrotor technology is viable for a military aircraft (e.g. V-22 Osprey), insufficient research has been undertaken on technologies critical to civil applications such as noise, terminal area operations, safety, passenger acceptance, weight reduction, and reliability. The Short Haul Civil Tiltrotor (SHCT) project focuses on noise reduction; cockpit technology for safe, efficient terminal area operations; and contingency power. To achieve acceptable levels of external noise in the terminal area, prop-rotor noise must be reduced by six decibels, A-weighted (dBA) over current technology. Complex flight profiles involving steep approach angles and multi-segmented approach paths will be developed to provide an additional 6-dBA reduction. To enable these approaches to be safely flown under all-weather conditions integrated and automated control laws and displays will be developed.

<u>SCHEDULE AND OUTPUTS</u>

Terminal Area Productivity:

Conduct simulation of full CTAS coordinated with FMS Plan: July 2000 Actual: August 2000	Successfully conducted full-mission simulation of Center-Terminal Radar Approach Control (TRACON) Automation System (CTAS) decision support tools operating in coordination with aircraft Flight Management System.
Complete demonstrations of all TAP-developed technologies and procedures Plan: September 2000 Actual: October 2000	Completed all of the demonstrations for the TAP project. Demonstrated all TAP technologies in a realistic NAS environments achieving a 12 – 15 % increase in single runway throughput and proving the ability to space aircraft closer than 3,400 feet on parallel runways while meeting all FAA safety criteria. This completes the TAP Project.

Advanced Air Transportation Technologies:

Develop, demonstrate and transfer extended terminal area decision support tools for arrival and surface operations in support of the FAA Free Flight Phase 1 Program Plan June 2000 Actual: June 2000	Completed field evaluations of individual decision support tools for management of arrival and surface traffic. Transferred technology to the FAA Free Flight Phase 1 Program. FAA is currently deploying systems to operational air traffic control facilities. Tools are in daily use at several air-traffic control facilities.
Develop and demonstrate transition airspace decision support tools for: ATC/airline operations centers and ATC/cockpit information exchange Conflict resolution Plan: September 2001	Develop and demonstrate transition airspace decision support tools. These tools will enable information exchange between ATC/airline operations centers and ATC/cockpits for collaborative decision-making. These tools will also enable prediction of aircraft conflicts both by ATC and flight crews.
Develop and demonstrate an inter-operable suite of decision support tools for arrival, surface and departure operations Plan: March 2002	Conduct a high-fidelity human-in-the-loop simulation demonstration of the inter-operable suite of decision support tools.

Short Haul Civil Tiltrotor:

Full-span database for low-noise rotor concepts and final noise code (TRAC) Plan: January 2000 Revised: March 2000 Actual: March 2000	Completed correlation of Tilt-Rotor Aeroacoustic Code (TRAC) with full-scale flight database for XV-15. Correlation completed for level flight, low-noise 3-degree and low-noise 9-degree approaches. TRAC predicted and validated the XV-15 noise profiles.

Comprehensive mission simulation database of integrated cockpit and operating procedures for complex, low-noise flight paths Plan: September 2001	Conduct mission simulations to develop a comprehensive database for complex, low noise flight paths of a civil tilt-rotor with integrated cockpit and operating procedures. The simulations will integrate noise data, operating procedures and cockpits systems evaluated in earlier simulation and flight experiments.
Large scale database for validation of rotor noise reduction and validated design for noise capability (TRAC) Plan: September 2001	Acquire a large-scale database for validation of rotor noise reduction and validated design-for-noise capability.

Aviation System Technology Advanced Research:

Requirements and preliminary design of VAST complete Plan: September 2002	Complete the definition of the requirements and the preliminary design of a Virtual Airspace Simulation Technology (VAST) environment for unparalleled real-time testing and validation of new and innovative air traffic management concepts.
Identification of first new operational concept complete Plan: September 2002	Complete the identification of the first new revolutionary air traffic management operational concept for investigation using the VAST capability.

ACCOMPLISHMENTS AND PLANS

The **Terminal Area Productivity** (TAP) project was completed in FY2000 with the conduct of the final demonstrations of developed technologies and procedures. Full-mission simulations were conducted to demonstrate integration of airborne flight management systems (FMS) with ground-based ATC decision support tools (CTAS). A simulation was conducted to develop the operational procedures for the Airborne Information for Lateral Spacing (AILS) concept for simultaneous independent approaches to closely spaced parallel runways while interacting with other air traffic. In addition, an integrated demonstration of all the completed technologies for the Aircraft Vortex Sensing System (AVOSS) was conducted at the Dallas Ft.-Worth airport. The TAP project met or exceeded all three of its performance goals: (1) Increase non-visual single-runway throughput by 12 to 15%; (2) Reduce lateral spacing below 3400 feet for independent operations on parallel runways; and (3) Demonstrate equivalent instrument/clear weather runway occupancy time.

During FY 2000, the **Advanced Air Transportation Technologies** (AATT) project completed the development, field evaluation and transfer of three decision support tools to the FAA Free Flight Phase 1 Program for the management of arrival and surface operations in the terminal area: Traffic Management Advisor (TMA), Passive Final Approach Spacing Tool (pFAST); and the Surface Movement Advisor (SMA). NASA delivered source code, documentation and assistance in the operational software validation process. The FAA is currently deploying these decision support tools at key sites throughout the National Airspace System to improve the capacity of the extended terminal area airspace. Each of the tools is currently in daily use at several air-traffic control facilities in the NAS. These tools are the backbone of the FAA's introduction of decision support tools to improve the efficiency of the nation's Air Traffic Control System. The AATT Project also completed initial development and simulation; with live traffic data, of the Direct-to (D2) decision support tool to enable controllers to more directly route en route traffic for increased operational efficiency. The functionality of the tool was validated at Dallas-Ft. Worth with simulated traffic under normal Host maintenance procedures where the Host is taken off-line for testing during a light traffic period. Three beta test flights were successfully completed of the En-route Data Exchange (EDX) tool in which United Airlines B-777 aircraft state (position, velocity, weight, winds, etc.) and intent information was down linked to the Center-TRACON Automation System (CTAS) lab at Ames. This downlinked information will allow improved CTAS trajectory prediction capability based on increased accuracy aircraft information. Currently 10 United Airlines B-777 aircraft are equipped and are capable of automatically reporting aircraft status and intent information.

The Short **Haul Civil Tiltrotor** project demonstrated correlation of the Tilt-Rotor Aeroacoustic Code (TRAC) prediction with a full-scale flight database for the XV-15 tiltrotor. The correlation was completed for level flight, low-noise 3-degree and low-noise 9-degree approaches. TRAC predicted and validated the XV-15 noise profiles. In large-scale wind tunnel test, demonstrated a breakthrough level of noise reduction for the rotor of -12.5 dB for a low-noise approach condition using higher harmonic control (HHC) (a high frequency oscillation of the rotor blades). These reductions greatly exceed the project goal of 6dB. In conjunction with industry, conducted a flight research program to validate noise reduction flight profiles. Candidate flight path profiles were developed analytically and refined in piloted simulation. The flight investigation further refined the profiles and measured the noise footprints. The low-noise profiles were 7dB less than the baseline and meet the project goal of 6dB. A piloted simulation also was conducted to further refine the requirements for control and displays in adverse weather. These flight and simulation studies provide key results for the final mission simulation to be conducted next year.
During FY2001, the **Advanced Air Transportation Technologies** project will conduct field evaluations to demonstrate transition airspace decision support tools in support of (1) Information exchange between air traffic service providers, airline operations centers, and flight crews and (2) Conflict resolution. The decision support tools for information exchange (EDX) will demonstrate collaborative decision-making between ATC and the aircraft operators to optimize both ATC and airline operations. Conflict detection capabilities by both the ATC and aircraft will enable optimization of both overall traffic flow as well as individual aircraft flight trajectories.

The **Short Haul Civil Tiltrotor** project will be completed in FY2001. The project will conduct a comprehensive mission simulation to integrate all of the knowledge learned from the previous simulation and flight investigations: low-noise flight paths, integrated displays, advanced control laws, and operating procedures. The simulation will examine integrated cockpit and operating procedures for complex, low noise flight paths of a civil tiltrotor operating in a full-mission environment. Also, a large-scale tiltrotor database will be acquired for use in validation of both rotor noise reduction and a design-for-noise capability. The Tiltrotor Aeroacoustic Code (TRAC) computer program will enable the predictive capability.

During FY2002, the **Advanced Air Transportation Technologies** project will demonstrate through simulation an interoperable site of decision support tools for arrival, surface and departure operations. Development work in FY2002 will lead to the transfer of surface management system technology to the FAA Free Flight Phase 2 Program in FY2004. The capability will reduce arrival and departure delays and inefficiencies that occur on the airport surface due to surface issues and downstream restrictions.

During FY2002, the **Virtual Airspace Modeling** project will develop the requirements and preliminary design for a high fidelity modeling and simulation environment for the real-time investigation and validation of revolutionary operational and technological concepts for the next generation of aviation system. The project will also identify and define the first new operational concept for future investigation using the new virtual airspace simulation technology capability.

BASIS OF FY 2002 FUNDING REQUIREMENT

AVIATION SAFETY PROGRAM

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Aviation Safety Program	64,394	70,844	70,000

PROGRAM GOALS

The worldwide commercial aviation major accident rate has been nearly constant over the past 2 decades. While the rate is very low (approximately one hull loss per 2 million departures), increasing traffic over the years has resulted in the absolute number of accidents also increasing. The worldwide demand for air travel is expected to increase even further over the coming 2 decades - more than doubling by 2017. Without an improvement in the accident rate, such a traffic volume would lead to 50 or more major accidents a year — a near weekly occurrence. Given the very visible, damaging, and tragic effects of even a single major accident, even approaching this number of accidents would clearly have an unacceptable impact upon the public's confidence in the aviation system, and impede the anticipated growth of the commercial air-travel market. The safety of the general aviation (GA) system is also critically important. The current GA accident rate is many times greater than that of scheduled commercial transport operations. The GA market may grow significantly in future years. Safety considerations must be removed as a barrier if this growth is also to be realized. Controlled-Flight Into Terrain (CFIT) and loss of control are the two largest commercial accident types, with weather, approach and landing, and on-board fire as additional significant categories. Human error is cited above all other issues as the prime contributing factor. For GA, weather issues, CFIT, and loss of control also dominate the accident statistics.

In February 1997, to aggressively address these issues, a new national goal to reduce the fatal accident rate for aviation by 80% within 10 years was established. This national aviation safety goal is an ambitious and clear challenge to the aviation community. NASA responded to the challenge with an immediate major program planning effort to define the appropriate research to be conducted by the Agency. Four industry- and government-wide workshops were conducted in early 1997 to define research needs. Four hundred persons from over one hundred industry, government, and academic organizations actively participated in setting the research investment strategies. This led to NASA's aviation safety initiative and a redirection of the Aeronautics Research and Technology Base in FY 1998 to immediately augment aviation safety research. The Aviation Safety Program (AvSP) is NASA's next step in responding to the challenge. The goal of the AvSP is to develop and demonstrate technologies that contribute to a reduction in the aviation accident fatal rate by a factor of 5 by the year 2007 compared to the 1994-1996 average.

STRATEGY FOR ACHIEVING GOALS

The NASA AvSP approach for contributing to the national goal is to develop and demonstrate technologies and strategies to improve aviation safety by reducing both aircraft accident and fatality rates. Program planning gives high priority to those strategies that address factors determined to be the largest contributors to fatal accidents as well as those that address multiple classes of factors. Research and technology development will address accidents involving hazardous weather, CFIT, human-error-caused accidents and incidents, and mechanical or software malfunctions. The safety program will emphasize not only accident rate reduction, but also a decrease in injuries and fatalities when accidents do occur. The program will also develop and integrate information technologies needed to build a safer aviation system--to support pilots and air traffic controllers--as well as provide information to assess situations and trends that might indicate unsafe conditions before they lead to accidents. The focus of each program project is the development of one or more prevention, intervention, or mitigation strategies aimed at one or more causal, contributory, or circumstantial factors associated with aviation accidents.

The AvSP will work as partners with the Federal Aviation Administration (FAA) in implementing the program and will maintain close coordination with the Department of Defense and other government agencies. Additionally, the program will work in concert with the full spectrum of commercial, rotorcraft, and GA industry manufacturers, suppliers, and operators in implementing the effort. Langley Research Center (LaRC) is the program's Lead Center and works as a team with program personnel at Ames (ARC), Glenn (GRC), and Dryden (DFRC) Research Centers.

The AvSP programmatic and technical approach has been developed in close cooperation with the FAA as well as the broad aviation community. The Aviation Safety Program Manager is a member of the Commercial Aviation Safety Team and the General Aviation Joint Steering Committee, the government/industry leadership groups developing and managing the overall National safety strategies. NASA aviation safety research and development efforts will therefore complement both FAA and industry activities as a coordinated overall effort.

Based on the AvSP goal, the criteria for program mission success is to develop technologies that, when implemented by the aviation community, will contribute to a reduction of the civil aviation rate. The program mission success criteria are to produce:

- Human-error assessment methodologies that allow system designs and procedures to be analyzed for error susceptibility – validated in piloted simulation

- Health and Usage Monitoring technologies that enable real time and trending status of critical on-board aircraft systems – demonstrated in flight

- Affordable technologies and systems for the data-linked communication and on-board graphical display of critical aviation weather information both nationally and internationally – demonstrated in flight

- Turbulence modeling and detection technologies that allow for predictive warning and/or avoidance of severe turbulence encounters - demonstrated in flight

• Synthetic Vision technologies and feasible, demonstrated system concepts that provide immediate clear day-equivalent visual awareness and avoidance of world-wide terrain and obstacles in any weather or light condition – demonstrated in flight

• Precision approach and landing technologies and displays that provide intuitive guidance and piloting decision support worldwide, at any runway, at any airport, for both general and commercial aviation – demonstrated in flight

• Advanced structural and material designs that demonstrate 20%-40% improvement in crash survivability and fire hazard mitigation – demonstrated in simulation

• Integrated aviation system monitoring tools and infrastructure design accessible both nationally and internationally, allowing regular operational assessments to identify unsafe trends before they become accidents – operational with at least two major airlines

Associated with each technology development effort will be on-going activities by NASA and the FAA to motivate and assist in the implementation of program outputs into the aviation community. NASA researchers will stay involved to help program "outputs" become "outcomes." This process will mean that NASA will work with industry and FAA partners to progress technologies through implementation.

The Technical Program is comprised of six major projects:

Aviation System Monitoring and Modeling (ASMM)--This project provides decision-makers in air carriers, air traffic management, and other air services providers with unprecedented in-depth measures of health, performance, and safety of flight operations in the national aviation system. Capitalizing on revolutionary advances in information technologies and digital communications, ASMM applications will enable definition of operational and safety baselines and trends, and identification of developing conditions that could compromise aviation safety. ASMM outputs will also provide technology and procedure developers with the capability for reliable predictions of the system-wide effects of potential changes introduced into the aviation system.

System-Wide Accident Prevention (SWAP)--This project addresses aviation safety issues associated with human error and procedural non-compliance, which are broadly applicable throughout the national aviation system. Since human error is cited as a factor in 60%-80% of aviation accidents, generally reducing or mitigating the effect of human error will result in significant improvements in the fatal accident rate.

Single Aircraft Accident Prevention (SAAP)--This project develops and supports the implementation of safety technologies for in-flight applications. Current accident categories that SAAP will address are loss of control in flight and pilot errors resulting from hardware and/or software failures. Human factors issues and considerations cut across all of these categories and will be an integral part of the technology development process. Both commercial transport and GA vehicle classes are included.

Weather Accident Prevention (WxAP)--This project will develop and support the implementation of technologies to reduce the fatal accident rate induced by weather hazards. Graphical cockpit weather displays and pilot decision making support tools will be developed for avoiding icing, thunderstorms, and other weather issues. In addition, forward looking sensors for detecting severe turbulence conditions will be demonstrated in flight.

Synthetic Vision Systems (SVS)--CFIT commercial transport accidents and a significant percentage of GA accidents result from visibility-induced pilot errors (when terrain, obstacles, or the horizon are not visible at night or in poor weather). By developing precision navigation technologies, high-resolution terrain databases, weather penetrating sensors, and graphical cockpit displays, SVS project development will provide commercial and GA pilots with clear out-the-window views regardless of the actual visibility conditions. Specific technology applications include display of terrain, precision approach and landing guidance and displays, and low visibility surface operations.

Accident Mitigation (AM)--This project will develop, enable, and promote the implementation of technologies to increase the human survival rate in survivable accidents, and to prevent in-flight fires. The number of survivors can be increased in accidents that are of the severity level where some, but not all, passengers survive. Fatalities are the result of impact factors, fire/smoke, or some combination of both. Project technology developments include crashworthy structural and system design methods as well as in-flight and post-crash fire prevention.

<u>SCHEDULE AND OUTPUTS</u>

Preliminary integrated program assessment Plan: January 2000 Actual: January 2000	Complete a preliminary safety impact assessment of AvSP integrated program Assessment Status: Reviewed and concurred by the Aviation Safety Program Executive Council
Apply Aircraft Performance Monitoring System (APMS) to Air Traffic Control (ATC) Plan: March 2000 Actual April 2000	Demonstrate application of APMS concepts & methodologies to ATC for performance monitoring Status: Performance Data Analysis and Reporting Systems (PDARS) software in daily operation at Southern California ATC site.
CD-ROM Icing Training Module Plan: December 1999 Actual: May 2000	Developed CD-ROM icing training module for General Aviation and commuter pilots. Status: Interactive CD-ROM developed and distributed to General Aviation commuter pilot community

Simulation Database for Adverse Conditions and Loss of Control Plan: September 2000 Revised: January 2001	Complete development of a preliminary simulation database, mathematical models and 6 degree-of-freedom vehicle simulations to characterize adverse conditions, failures, and loss of control Status: Wind tunnel model developed and ready for testing. Wind tunnel upgrade repair delayed test entry by 2 months.
Initial Aviation Weather Information Network (AWIN) Concept Flight Evaluation Plan: September 2000 Actual: November 2000	Flight Evaluation of initial national capability for digital data link and graphical display of weather information. Status: AWIN system developed and operated on Boeing 757 test aircraft. Two major airlines ready to begin in-service system evaluation.
Flight Demonstration of Runway Incursion Prevention Technologies Plan: September 2000 Actual: October 2000	Concept demonstration of integration of air traffic control runway incursion information onto aircraft flight deck displays. Completed airborne and ground-based systems testing at Dallas / Ft. Worth airport in October 2000. Pilot comments confirmed that the system provided increased situational awareness of the airport to aid in runway incursion avoidance and surface safety. Demonstrations were conducted for representatives from the Office of the President, FAA/ DoT. Airport, airline, and major news media. Status: Flight testing and concept demonstration successfully completed at Dallas/Ft. Worth airport
Flight Crew knowledge standards Plan: December 2000	Complete the development of flight crew knowledge and proficiency standards for automation.
Tools for causal and risk assessment Plan: September 2001 Revised: March 2002	Demonstrate in an operational environment, tools for merging heterogeneous databases to aid causal and risk assessment.
Onboard health management system Plan: September 2001	Define an architecture for an integrated onboard health management system
SVS retrofit concepts Plan: September 2001	Evaluation of SVS concepts in simulations and flight-tests. Measurement tools developed for the analysis of SVS retrofit concepts.

Reduce fuel system flammability Plan: September 2001	Successfully complete the experimental and analytic laboratory environment demonstration of fuel system modifications to reduce flammability.
Advanced Fire detection systems Plan: September 2001	Complete the design criteria for low false-alarm fire detection systems.
Safety Improvement Concepts developed Plan: September 2001	Conceptual designs of safety-improvement systems are completed for all projects in September 2001.
Flight Demonstration of Forward- Looking Warning System Plan: June 2002	Flight test of turbulence detection system results in 90% or better detection rate for moderate turbulence within 1 minute of encounter.
Demonstration of Flight Critical System Validation Method Plan: June 2002	Documented results of closed-loop laboratory test methods for the validation of complex flight critical system architectures.
Computational Models of present and future contexts Plan: June 2002	Perform computational modeling of operational situations that have high error probabilities, along with potential solutions for error reduction or mitigation.
Interim Integrated Program Assessment Plan: June 2002	Interim assessment impact assessment of AvSP integrated program completed Projected impact on accident rates for research projects completed and provided in a summary report
NAOMS adds the GA pilot community to the survey system Plan: September 2002	Active participation by a significant sector of the GA community with 60% of questionnaires returned

Demonstrate national capability for graphical display of weather information Plan: September 2002	Transport and GA graphical displays that provide timely, affordable, and quality U.S. weather information access and flight path relevant presentation.
Analysis tools for structural Crashworthiness prediction Plan: September 2002	Existing codes updated and documented and crash dynamics predictions validated with crash test data delivered to industry.
Demonstrate loss of control and Recovery models in high-fidelity 6 –DOF simulation environment Plan: September 2002	Deliver results of enhanced six-degree of freedom simulations with documentation of math models characterizing vehicle dynamics for outside of the normal envelope conditions.

ACCOMPLISHMENTS AND PLANS

In FY 2000, the first year of the AvSP, the System-Wide Accident Prevention project has developed and demonstrated an icing training module on CD-ROM for GA and commuter pilots. This enabled the broad dissemination of critical weather safety information to the national aviation community. The Aviation System Monitoring and Modeling project has demonstrated the application of Aircraft Performance Measurement System concepts and methodologies to ATC systems for performance monitoring. This work has taken successful aircraft-based monitoring technologies and applied them to the broader context of the national airspace system risk identification and performance improvements. The software tools are now in daily use at multiple air traffic control facilities. Airline evaluations and operational use of aircraft performance measuring software and analysis tools have also been conducted. In the Accident Mitigation project, on-board inert gas and oxygen generation system concepts for fire prevention and emergency use have been defined and structural crashworthiness design analysis prediction codes development selections will be completed in the near future. The Weather Accident Prevention project demonstrated, in flight, commercially ready graphical weather display systems that will now enter in-service evaluations with multiple airlines. The Synthetic Vision Systems project completed concept evaluation flight tests at the terrain-impacted airport in Asheville, North Carolina, and initiated Runway Incursion Prevention testing in Dallas/Ft. Worth airport.

For FY 2001, the System-Wide Accident Prevention project will complete development of flight crew knowledge and proficiency standards for automation and deliver them to industry for evaluation and develop prototype-training materials for evaluating skill-specific maintenance resource management. The Single Aircraft Accident Prevention project will deliver results of enhanced six-degree of freedom simulations with documentation of math models characterizing vehicle dynamics for outside of the normal envelope conditions. Single Aircraft Accident Prevention also will define architectures for integrated onboard health management systems. These designs will provide sufficient criteria to support development of concept prototypes to be used for simulation and flight demonstrations. The Weather Accident Prevention project will complete flight evaluations of an initial national capability for digital data link and graphical weather information displays in an aircraft cockpit. This will result in a cockpit "weather channel" for national and worldwide commercial airline and GA benefit. Flight-testing and selection of concepts for continued development will be conducted for clear-air turbulence detection systems. The Accident Mitigation project will demonstrate, in experimental and analytic laboratory environments, a fuel system modification to reduce flammability, and validate system designs in a representative fire environment experiment, showing improved reliability and low false-alarm characteristics. The Synthetic Vision Systems project will down-select concepts suitable for retrofit in commercial, business, and general aviation aircraft, and investigate the use of weather-penetrating sensors as means for independently monitoring the integrity of Synthetic Vision Systems. This project will also conduct flight demonstration tests of FAA and NASA runway incursion technologies integrated on an aircraft flight deck, which will be completed at Dallas/Ft. Worth Airport.

In FY 2002, the Aviation System Monitoring and Modeling project will demonstrate tools for merging heterogeneous air service providers' databases to aid causal analysis and risk assessment. Also, this project will add provisions to include the GA pilot community to the NAS Operational monitoring service (NAOMS) survey system. The System-Wide Accident Prevention project will determine, through simulations, the error probabilities of present and future hazard/risk contexts and the probability of reducing the likelihood of error given proposed mitigation strategies. The Single Aircraft Accident Prevention project will demonstrate high-fidelity 6 degree of freedom simulation models of loss of control and recovery conditions, as well as simulations of subsystem concepts for the prevention and recovery from these conditions. Also, this project will demonstrate through flight testing a proof of concept system for rotorcraft health and usage management. The Weather Accident Prevention project will demonstrate a national capability for digital data link and graphical display of weather information. This project will also demonstrate a forward-looking, onboard turbulence warning system. In the Accident Mitigation project, analysis tools for aircraft structural crashworthiness prediction will be validated.

BASIS OF FY 2002 FUNDING REQUIREMENT

ULTRA EFFICIENT ENGINE TECHNOLOGY

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Ultra-efficient engine technology...	68,306	47,894	40,000

PROGRAM GOALS

NASA's role in civil aeronautics is to develop high risk, high payoff technologies to meet critical national aviation challenges. Currently, a high priority national challenge is to ensure U.S. leadership in aviation in the face of growing air traffic volume, new safety requirements, and increasingly stringent noise and emissions standards. NASA's role in aeronautics is also to support the Department of Defense (DoD) in maintaining superior defense capability. Propulsion has led the way for new generations of aircraft with breakthroughs in performance, reliability, and environmental compatibility. A prime example of NASA's contribution to technological advances in propulsion is the high bypass turbofan. This engine enabled the economic success of wide-body transport aircraft and achievement of new levels of fuel efficiency and dramatically reduced noise as compared to the earlier generation of jet aircraft. The attainment of Aerospace Technology Enterprise goals requires comprehensive propulsion technology research and development spanning a broad range of aircraft applications from subsonic through hypersonic. The timing is right to invest in breakthrough technologies for a new breed of radically improved propulsion systems to power a new generation of aircraft required in the increasingly constrained airspace system.

NASA has a successful history of leading the development of aggressive high payoff technology in high-risk areas, ensuring a proactive approach is taken to developing and transitioning technology that will both be required for meeting anticipated future requirements and for providing the technical basis to guide policy by determining feasible technical limits. The Ultra-Efficient Engine Technology Program addresses the most critical propulsion issues facing the Nation in the new millennium: performance and efficiency. In order to sustain the desirable forecasted growth of this important industry, these issues must be addressed without dampening this growth and therefore must improve performance and efficiency without incurring environmental penalties. Additionally, it is important to sustain the high reliability and safe operation without impacting the economics of operations. These propulsion technologies will also be of significant benefit to military engines where performance improvement is the principal goal driving DoD propulsion development for future military aircraft.

STRATEGY FOR ACHIEVING GOALS

The Ultra-Efficient Engine Technology Program is planned and designed to develop high-payoff, high-risk technologies to enable the next breakthroughs in propulsion systems to spawn a new generation of high performance, operationally efficient and economical, reliable and environmentally compatible U.S. aircraft. The breakthrough technologies are focused on propulsion component and high temperature engine materials development and demonstrations enabling future commercial and military propulsion systems which are greatly simplified, achieve higher performance, and have potential for much reduced environmental impact with a broad range of aircraft application. Seven investment areas form the basis for the technical approach: emissions reduction, to develop the technology necessary to address efficient high temperature, high pressure, high performance systems and to reduce emissions; materials & structures, to address the barrier technologies and expand the knowledge databases associated with high temperature; turbomachinery, to develop highly coupled/loaded engine component technologies incorporating breakthrough features with potential for integrated propulsion demonstrations; propulsion-airframe integration to develop approaches and technologies for integrating next generation propulsion systems with revolutionary aerospace vehicle designs so as to maintain high levels of installed propulsion system performance; intelligent propulsion controls to leverage the emerging intelligent systems and information technologies along with propulsion component and materials technologies to apply to revolutionary propulsion system architectures; integration & assessments, to understand the complexity of interplay among technology benefit, tradeoff and impact; and integrated component technology validations to demonstrate the ability to integrate technologies and achieve revolutionary levels of sub system/system performance.

NASA's investments will develop the underlying understanding and design information to mitigate both the risk and cost of applying the technology-based solutions. The success of this program is dependent on partnerships to enable transfer of the resulting technology. As a result, a key element of this program is to develop high-payoff technologies, in cooperation with DoD, the Federal Aviation Administration (FAA), the Environmental protection Agency (EPA), the U.S. aeronautics industry and academia, to benefit the public.

The Glenn Research Center is the lead center for the UEET Program and six of the seven projects (emissions reduction, materials and structures, turbomachinery, intelligent propulsion controls, propulsion system integration and assessment, and integrated component technology validation). Langley Research Center has project management responsibility for the propulsion-airframe integration project and Ames Research Center has sub project management for portions of the emissions and materials and structures projects. Goddard Space Flight Center provides critically important supporting research in the atmospheric assessment subproject of the integration and assessment project.

SCHEDULE AND OUTPUTS

Emissions Reduction: Combustion research facility upgrade completed Plan: September 2000 Actual: September 2000	Complete the development and fabrication of the upgrade to the Combustion Research Facility, a unique world class facility, which is required for testing of combustor configurations (flame tube and sector) required for future ultra-high pressure ratio engine cycles. The design and fabrication of the rig was completed according to schedule (September 2000). The rig will be operational the second quarter of FY 2001.

Emissions Reduction: Select 70% emissions reduction concept for full combustor evaluation Plan: September 2000 Actual: September 2000	Demonstrate in a laboratory combustion experiment (flame tube) an advanced turbine-engine combustor concept that will achieve up to a 70% reduction of oxides of nitrogen (NOx) emissions based on 1996 ICAO standard. (0R1) Flame tube tests performed at NASA Glenn Research Center demonstrated NOx reduction levels of up to 83%.
Materials & Structures: Complete high temperature engine material down-select Plan: September 2000 Actual: September 2000	Complete selection of those materials systems that will be developed for complex geometry such as cooled turbine vanes with thermal barrier coating and capable of sustained 3100°F turbine rotor inlet temperatures Completed selection of thermal barrier coating after evaluating over 33 chemistries. The selected thermal barrier coating is projected to have capabilities far in excess of the current state-of-the-art. The ceramic matrix composite (CMC) material selected is based upon the CMC material developed in the High Speed Research's (HSR) Enabling Propulsion Materials (EPM) project.
Intelligent Propulsion Controls: Plan: September 2000 Actual: September 2000	Complete initial laboratory studies of approaches for active combustion control. Initial laboratory studies were successfully completed through initial flametube tests at the Ames Research Center.
Integration & Assessment: Preliminary Technology Benefits Assessment Plan: September 2000 Actual: September 2000	Assess UEET technology impacts on meeting program goals. Assess all UEET technology impacts on meeting program goals for at least three classes of aircraft. Include assessment of performance, weight, and environmental indicators. Completed assessment of UEET technology impacts for four classes of aircraft—a 300 passenger large subsonic transport, a 50 passenger regional jet transport, a 300 passenger supersonic civil transport, and a 10 passenger supersonic business jet.
Propulsion-Airframe Integration: Prediction of propulsion-airframe integration Plan: October 2000 Revised: September 2001	Complete selection of the most promising simulation approach for predicting propulsion-airframe integration effects for unconventional aerospace vehicles. (1R02D) The milestone was slipped to allow for additional comparisons to be made with existing test data sets so as to reduce the risk in the selection process.

Turbomachinery: Flow Control Concepts for advanced propulsion systems Plan: September 2000 Revised: September 2001	Complete the selection of the most promising flow control concepts that will be developed for application to the turbine components of advanced propulsion systems. (1R02a) Milestone split into flow control concepts for three components—compressor, turbine, and fan. The compressor flow control concept selection was completed in June 2000, the fan is expected to be completed in March 2001, and the turbine is expected to be completed in September 2001.
Integration and Assessment: Definition of advanced propulsion options Plan: September 2001	Complete definition of advanced propulsion options incorporating UEET low emissions combustor, high temperature materials, and highly loaded turbomachinery candidate technologies. (1R02c)
Materials and Structures: High Temperature Turbomachinery Disk Alloy Plan: September 2001	Demonstrate by September 2001 the upper temperature limit of a turbomachinery disk alloy as a function of stress.
Integrated Component Technology Validation: Aspirating Seal Demonstration Plan: March 2002	Demonstrate engine aspirating seal technology in partnership with industry.
Integrated Component Technology Validation: Integrated Component Technology Demonstrations Plan: April 2002	Develop an Integrated Component Demonstration Plan for collaborative tests of engine demonstrators incorporating UEET technologies for large and small thrust class engines.
Emissions Reduction: Initial Low NOx Combustor Sector Test Plan: September 2002	In sector combustor tests, demonstrate initial 70% low NOx reduction, relative to 1996 International Civil Aviation Organization (ICAO) standards, for Landing/Takeoff conditions in subsonic engines.
Materials and Structures: Ceramic Thermal Barrier Coating System Plan: September 2002	Select a low conductive ceramic Thermal Barrier Coating (TBC) to achieve a significant increase in temperature capability.

ACCOMPLISHMENTS AND PLANS

Emissions Reduction: In FY 2000, a world class high pressure ratio combustion research facility upgrade was completed to allow parallel operation of basic combustion research for combustion diagnostics and physics based model calibration and for flame tube and sector testing to validate advanced high performance combustor designs. This facility allows for realistic testing of combustion concepts applicable for the high pressure ratio engine cycles envisioned which will fully utilize the technologies developed in the UEET program to achieve revolutionary advances in gas turbine engine performance. Initial tests in this upgraded facility will occur in FY2001. In FY 2000, flame tube tests were conducted to identify the most promising approaches for achieving the 70 percent NOx reduction goal. These tests conducted at GRC demonstrated NOx reduction levels of up to 83% in flame tubes, the first step in combustion hardware testing. In FY2001, the flame tube tests will continue and the results will be used to design and initiate fabrication of sector configurations (the next step in combustion hardware testing) of ultra-low emissions configurations for subsonic engine applications. Model tests will be conducted in FY2001 and 2002 in both industry and government facilities as appropriate. The most promising configurations determined from the sector tests will be tested in full annular rig configurations, the third step in combustion hardware testing. State of the art instrumentation will be used to measure particulate and aerosol characteristics of these advanced combustor configurations. These results will be used in atmospheric impact assessments to be accomplished as part of the Integration and Assessment project.

Materials & Structures: In FY2000, the selection of those materials systems that will be developed to the subcomponent, complex part scale in this program was completed. The suite of high temperature materials from which this selection will be made is focused only on those critical to enable the high performance 21st Century propulsion systems. An initial high priority activity completed in FY2000 was the selection of the most promising approaches for developing a low-conductivity thermal-barrier coating, a critical constituent for a high-temperature turbine airfoil material system. Over 33 chemistries for potential TBC's were investigated in laboratory tests conducted at GRC and the most promising chemistry was selected. One critical material system, Ceramic Matrix Composites (CMC), is essential to both future commercial and military engines. This program is the only national effort in CMC's and is a key technology where DoD is reliant on NASA. CMC work in FY2000 focused on establishing the upper temperature limit of the material developed in the High-Speed Research (HSR) Program. Effort also was initiated in FY2000 to evaluate the Ultra-High Temperature Ceramic (UHTC) material initially developed by ARC for Shuttle applications for gas turbine combustor liner application.

In FY2001, the upper temperature limit will be established for the advanced Nickel based material developed in the HSR Program for turbomachinery disk applications as well as for the single crystal Nickel based turbine blade material also developed in the HSR Program. The feasibility of the ultra-low thermal conductivity TBC will be established in FY01 through laboratory testing. Work was also initiated in FY2001 to evaluate the feasibility of Silicon Carbide nanotubes for structural applications related to gas turbine engines and to develop computational materials tools to develop the chemistry of next generation single crystal Nickel based alloys

In FY2002: optimization efforts relative to the TBC will be completed and efforts initiated to support a rig test of coated turbine blades in the FY2005 time period; initial laboratory tests will be completed to evaluate the design features of the CMC turbine vane; and evaluations of the ARC UHTC material for combustor liner applications will be completed.

Turbomachinery: In FY2000, a number of computationally based studies were initiated to evaluate approaches, including flow control, for achieving ultra-high loading of rotating turbomachinery components (fan, compressor, and turbine). A key part of achieving revolutionary turbomachinery performance increases is the use of flow control to allow increased turbomachinery performance in fewer stages. Fewer stages will enable a smaller, lighter engine that will save fuel costs. The flow control concepts were selected for compressor component applications in FY2000 based upon these studies. Work was also initiated on the design of a two-stage proof-of-concept compressor configuration, which would demonstrate experimentally the feasibility of the approaches being pursued in the UEET Program for achieving stage loading far in excess of the current state-of-the-art. Work was initiated in FY2000 on the design of a unique turbine component test facility (dual spool turbine facility (DSTF)) required for demonstrating the UEET program goals. This facility will allow for realistic configuration testing of highly loaded, closely coupled turbine designs emphasizing the understanding of the flow physics.

Flow control concepts for the fan and turbine components will be selected in FY2001 again based upon computational simulations. The most promising approaches for these components will be evaluated through proof-of-concept tests. (The fan component tests will be done in partnership with NASA's Quiet Aircraft Technology Program.) In FY2001, the detailed design of the unique world class turbine test facility will be initiated with completion scheduled for FY2002. In FY2001, evaluations will be conducted of a NASA developed turbine heat transfer simulation (GlennHT) using data supplied by industry. This simulation tool emphasizes the physics based modeling approach to predicting heat transfer as opposed to correlation approaches that represent the current state of the art.

In FY2002: the experimental testing of the two-stage proof-of-concept highly loaded compressor configuration will be completed and the results used in the design efforts of a four stage configuration. (This four stage configuration has projected performance levels (in terms of loading and efficiency) far in excess of the current state-of-the-art); the detailed design of the DSTF facility will be completed; and the initial evaluation of the GlennHT simulation tool will be completed.

Propulsion-Airframe Integration: In FY2000 a selection was to be made of the computational fluid dynamics simulation tool to be used to evaluate the installed performance of the engine concepts being evaluated. However this milestone was slipped to FY2001 to allow additional available experimental data to be employed in the selection process which will reduce the risk of the decision. In FY2000, evaluation efforts were conducted of candidate sensors and actuators required for the active flow control concepts being pursued.

In FY2001, the design and fabrication efforts will be completed for a small-scale active flow control demonstration model. This model will utilize the sensors and actuators that were selected during FY2000 activities. Active flow control technologies show great promise for reducing length and therefore weight of advanced propulsion system inlet designs as well as internal flow passages. In FY2001, the selection will be made of a simulation tool to be used for evaluating installed engine performance on revolutionary air vehicle configurations.

In FY2002, laboratory tests will be completed to evaluate the feasibility of the active flow control and shape control concepts being evaluated. Efforts will be initiated in FY2002 for the FY2003 test of a blended wing body (BWB) configuration for experimental evaluation of the computational methodology being utilized in the program.

Intelligent Propulsion Controls: In FY2000 and 2001, initial laboratory experiments are being conducted to assess active combustion control concepts for emissions reduction and turbine engine life extension potential. The initial tests conducted in FY2000 at Stanford University have yielded very positive results. Efforts in FY2001 and 2002 will focus on evaluating the most promising approaches in more realistic combustor configurations (as part of the emissions reduction project). Parallel efforts are being conducted to model the active combustion control concepts using tools such as the National Combustor Code (NCC) and the Large Eddy Simulation (LES) methods. These computational tools initially will be calibrated/validated through comparison with experimental tests and then be used to guide the experimental efforts in the outer years of the program.

Efforts will be completed in FY2001 to determine projected system payoffs of intelligent control architectures for future gas turbine engines. These studies will provide guidance for additional UEET technology development efforts in the outer years of the project. Initial experimental and analytical efforts in the project will focus on the evaluation and selection of promising approaches for wireless sensors that will be a key part of any intelligent engine architecture of the future. In FY2001, the UEET Program will partner with the RevCon program to acquire data on a wireless sensor installed on an engine of the NASA C-17 testbed aircraft at DFRC. This real world data will provide important early on understanding which will help guide the direction of the project.

Integration & Assessment: In FY2000, revolutionary propulsion system concepts were defined for an array of both low and high-speed vehicle applications. These propulsion system concepts will incorporate the suite of UEET technologies being developed in the other projects (i.e. ultra-low emissions combustor, highly loaded turbomachinery, materials and structures, propulsion airframe integration, and intelligent propulsion system controls) and projections of the revolutionary advances in system and vehicle performance will be made. In FY2001, a selection will be made of the propulsion system concept for which detailed, multi-disciplinary simulations will be conducted in FY2002 and beyond. These simulations will be performed using tools such as those provided by the High Performance Computing and Communications (HPCCP) and Intelligent Synthesis Environment (ISE) Programs. In FY2001 additional reference propulsion systems and vehicles will be added to the evaluation (i.e. hypersonic cruise/access to space and military transport). In FY2001, the metrics evaluation process will be finalized that will be used to track and report the status of the UEET Program to interested/involved stakeholders and customers on a regular basis. In FY2001, the initial results of the partnership efforts with the EPA to evaluate the impacts of UEET technologies on reducing the impact of future commercial aviation on the atmosphere and therefore improved quality of life will be completed. Partnership efforts with EPA and FAA will continue in FY2001 and 2002 to better understand the impacts of the trades which occur between emissions reductions (local air quality and cruise), airport noise reduction, and global warming (fuel burn reduction) and the impact on quality of life.

Integrated Component Technology Validation: In FY2000, plans were completed for an initial series of testbed demonstrations in partnership with industry to demonstrate two UEET technologies--CMC combustor liner and high temperature engine seals-–on existing engine test beds. In FY2001, design and fabrication efforts were completed to allow the testing in FY2002 of the 2200 deg F CMC combustor liner and an advanced high temperature engine seal designs. (These tests are being conducted in partnership with the industry with over 50 percent of the costs paid for by the industrial partner.)

In FY2000 studies were initiated with industry to determine additional opportunities for incorporating UEET component and materials technologies in partnership with DOD and/or the U. S. aeropropulsion industry using existing/available assets to accelerate the technology transition to commercial and military customers. The plans will be completed in FY2001 for the large thrust class engines (>20,000 lbs.) while the plans for smaller thrust class (<20,000 lbs.) will be completed early in FY2002. These studies also provide industrial partner perspectives on gas turbine designs required meeting the UEET goal of technologies for a 15 percent fuel burn reduction by 2005. This 15 percent reduction over 6 years of the program (or 2.5 percent per year average) represents a revolutionary challenge to the industry which has a history of 1 percent reduction in fuel burn per year in incremental improvement.

BASIS OF FY 2002 FUNDING REQUIREMENT

SMALL AIR TRANSPORT SYSTEM

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Small Air Transport System..	-----	8,980	15,000

PROGRAM GOALS

The nation's commercial air transportation system has reached a plateau. The system's current capacity is limited, and the limits are being reached. One solution lies in off-loading the large hub airports by expanding access to the over 5000 smaller airports, most without control towers, that can serve small cities and communities across the country. New small, efficient aircraft that can use these airports in all weather will allow point-to-point transportation rates two to three times faster than highway speeds. The mobility that this would allow is important to community vitality and economic opportunity which increasingly depends on access to rapid point-to-point transportation, in particular air transportation. Today, communities with airports capable of handling smaller aircraft in near all-weather conditions create significant economic benefits compared to communities that are not served by such landing facilities. The vision of the Small Aircraft Transportation System (SATS) program is inter-modal connectivity between public and private, air and ground modes of travel, in essence a true integration of the National Airspace System with the interstate highway system, intra-city rail transit systems, and hub-and-spoke airports.

The goal of the five-year Small Aircraft Transportation System program is to develop key airborne technologies and provide a proof-of-concept evaluation for precision guidance of small aircraft to virtually any touchdown zone at small airports. The objective is to allow the use of underutilized airports (including those without control towers, radar, or precision instrument approaches) as well as underutilized airspace (such as the low-altitude, non-radar airspace below 6,000 feet and the enroute structure below 18,000 feet). If successful, the initial SATS operating capabilities have the potential to create alternative means to respond to the demand for increased throughput in the National Airspace System in the near term. In the future, the SATS technology investments create potential alternatives for addressing the nation's challenge of unmet transportation demand related to the spreading of congestion on highways and in the major airport system.

STRATEGY FOR ACHIEVING GOALS

The approach for the SATS program is to enable the adoption of three operational capabilities that are not possible in the current NAS environment. These capabilities are:

– Higher Volume Operations at Non-Towered/Non-Radar Airports. Simultaneous operations by multiple aircraft in non-radar airspace at and around small non-towered airports can create accessibility to virtually any landing site in the nation in near all-weather conditions. This SATS operating capability has the potential to create an alternative to growth of NAS and can provide a lower infrastructure cost alternative.

– Lower Landing Minimums at Minimally Equipped Landing Facilities. Highway in the Sky graphical flight path guidance with artificial vision can create near all-weather access to any touchdown zone at any landing facility while avoiding land acquisition and approach lighting costs, as well as ground-based precision guidance systems such as ILS.

– Flight Systems for Improved Total System Performance. Human-centered automation will provide intuitive, easy to follow flight path guidance superimposed on a depiction of the outside world. Software enabled flight controls and flight planning will increase single-crew operational safety and mission reliability to two-crew levels. This SATS operating capability can lead to higher levels of safety and throughput for increasing numbers of users in the NAS.

To enable these operational capabilities, the program is focused on developing the key airborne technologies to support the creation and evaluation of SATS operating capabilities. The enabling technologies include: self-sequencing and separation systems, airborne Internet, software-enabled controls, emergency auto-land, and "highway-in-the-sky" guidance. Coordination with other NASA programs, particularly the Aviation Safety and Aviation Systems Capacity programs, will be maintained to ensure technologies being developed in those programs can be leveraged to support the SATS concept and facilitate success. Coordination with the ASC program is also important to ensure that a fourth operational capability, enroute procedures and systems for integrated fleet operations, is addressed to enable integration of SATS-equipped aircraft into the higher en route air traffic and controlled terminal airspace. These technologies would enable near all-weather operations by new generations of such aircraft at virtually any landing facility in the nation. Near all-weather means operational reliability in instrument meteorological conditions except those classified as severe or hazardous (i.e., severe icing, severe turbulence, thunder storm activity, etc).

The outcome of the five-year proof of concept includes experimental data from flight and simulation evaluations as well as analysis of the implications of technologies on transportation system decision-making. A significant part of the strategy for achieving the SATS goal is participation by the Federal Aviation Administration (FAA). A Memorandum of Agreement between NASA and the FAA will guide this participation and ensure that the technology development and proof-of-concept evaluations addresses issues associated with aircraft certification, flight standards, air traffic, and airports. It will also be the documentation that provides for sharing of resources and the conduct of joint planning and implementation. Similar memoranda will be established with state and local governments and local airport authorities, as participation by these organizations is also important for the success of SATS.

The technologies targeted for development are aimed at smaller aircraft used for personal and business transportation missions within the infrastructure of smaller airports throughout the nation. These missions include transportation of goods and travel by individuals, families, or groups of business associates. Consequently the aircraft are of similar size to typical automobiles and vans used for non-commercial ground transportation. They may be used for on-demand, unscheduled air-taxi transportation of these same user types. Various forms of shared ownership and usage will likely be a most common means of use. While the aircraft are not specifically designed for commercial operations, the targeted technologies would provide benefits to commuter and major air carrier operations in the hub-and-spoke system as well. For FAA regulatory purposes, SATS technologies are targeted toward aircraft with a maximum take-off weight (MTOW) less than12, 500 pounds.

SCHEDULE AND OUTPUTS

Partnership Alliance Established Plan: September 2001	The mechanism for partnering with NASA has been defined and established with at least one agreement signed with an external partner (state/local government, industry, or university
Systems Engineering Documents Baselined Plan: December 2001	Complete preparation of the baseline System Engineering documents (including the Operational Requirements Document, Functional Architecture, and Technical Requirements Document) for SATS concept and place under configuration management.
Technology Downselect For Flight Experiments Plan: December 2002	Select candidate technologies for experimental flight evaluations and complete FAA operational approval process.

ACCOMPLISHMENTS AND PLANS

In FY2001, initial baseline designs of the 2005 proof-of-concept evaluations were develop for two candidate geographic regions. These baseline designs form the basis for the system-level operational requirements and functional architecture needed for selection of candidate technologies during the 2003 flight experiments. Teams consisting of both public and industry partners developed the designs. NASA's partnership with the FAA was also firmly established with the signing of a Memorandum of Agreement between the agencies that provides the mechanism for transfer of resources from NASA to the FAA needed to conduct joint planning for the SATS Program. Additional activities for FY2001 include baseline measurements of the performance, stability and control, and noise contours for several flight research test beds that will be used in both the flight experiments in FY2003 and the proof-of-concept evaluations in FY2005. A key component for periodic assessment of the program was developed: a multi-disciplinary system model for assessing the impact of technology advances on doorstop-to-destination time (mobility and accessibility), economic and environmental impacts, and system cost. This will allow tracking of progress towards program goals and guidance for technology investments for the program.

Plans for FY2002 include completion of the program's baseline system engineering documents, including the Operational Requirements Document, Functional Architecture, and Technical Requirements Document. These documents form the basis from which all technology investment and downselect decision will be made. A key activity will be the development of a simulation environment in which the collaborative sequencing and self-separation algorithms can be assessed. Design philosophies that will guide the development of the flight-deck technologies will also be established. These products will allow the program to begin ground-based experiments in FY2002 that will be used to establish the technology sets that will be evaluated during the FY2003 flight experiments. In support of these experiments, modifications to the flight research test beds that will facilitate hardware and software evaluations will also begin in FY2002. The systems architecture for the "airborne internet", the high-bandwidth digital communications system necessary to enable the three operating capabilities, will be defined. Additional environmental and economic impact studies to support the program assessment process will be initiated in FY2002 as will a total vehicle integration and design study. This design study will form the basis for the vehicle portion of the system cost assessment.

BASIS OF FY 2002 FUNDING REQUIREMENT

QUIET AIRCRAFT TECHNOLOGY PROGRAM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Quiet Aircraft Technology Program	18,300	19,956	20,000

PROGRAM GOALS

The goal of the Quiet Aircraft Technology program is to contribute to the objectives of the Global Civil Aviation enabling technology goals, as stated in the Office of Aerospace Technology Enterprise Strategic Plan, "Reduce the perceived noise levels of future aircraft by a factor of two from today's subsonic aircraft within ten years, and by a factor of four within 25 years." Achievement of the 25-year goal will fulfill NASA's vision of a noise constraint- free air transportation system with the objectionable aircraft noise contained within the airport boundaries. Part of this vision is a transportation system with no need for curfews, noise budgets, or noise abatement procedures. Benefits to the public of achieving these goals include increased quality of life, readily available and affordable air travel, and continued U. S. global leadership.

A benefit of achieving the 10- year noise goal is that the 65 Day/Night (noise) Level (DNL) will be contained within the airport boundary for the majority of US airports. The significance of this is that this level of noise exposure is deemed so onerous that 65 DNL of noise exposure is a qualifying criterion for the FAA administered home noise insulation program. A benefit of achieving the 25- year noise goal is that the 55 DNL will be contained within most airport boundaries. The EPA has established that noise exposure less than 55 DNL is required to protect "public health and welfare". Containing the 55 DNL within the airport boundary achieves NASA's vision of objectionable airplane noise contained within the airport boundary.

Until objectionable aircraft noise is contained within airport boundaries through successful implementation of advanced noise reduction technology, noise from subsonic airplanes will continue to be an issue resulting in polices and procedures like curfews and noise budgets, for noise impact relief. While the results of previous NASA noise reduction research are incorporated in today's aircraft, even more aggressive technology is needed to address, not only the projected growth in operations, but also the public expectation for lower community noise impact.

For over 70 years, NASA with the FAA, industry, academia, and the Department of Defense have cooperatively developed critical aeronautical technologies for the future. Historically, NASA's perspective has been to take the long view and to make high risk, high potential payoff investments. The challenge to NASA is to develop critical technologies while fostering a national vision for aerospace technology development. NASA is unique in its expertise, facilities, and inherent government role to lead the technology development necessary to meet national community noise impact reduction requirements.

Noise impact of subsonic transportation is currently constraining the air transportation system through curfews, noise budgets and limits, and slot restrictions. The number of local noise related restrictions have grown worldwide from 257 in 1980, to over 832 in 2000. This dramatic growth in local noise- related constraints and the pressure for increased international noise certification stringency is indisputable evidence that the current noise impact status quo is not acceptable to the public. In addition noise issues are critically constraining the growth of the air transportation system by often delaying and sometimes inhibiting the expansion of needed airport capabilities – such as runway additions, expansions, or new airports. Today's noise-related constraints of the growth of aviation was predicted in the 1995 National Science and Technology Council (NSTC) Report *Goals for a National Partnership in Aeronautics Research and Technology.* The 1999 NSTC report National Research and Development Plan for Aviation Safety, Security, Efficiency, and Environmental Compatibility further predicts increasing community noise impact after the phase- out of nosier Stage II airplanes as the number of operations continue to increase. Projections for air travel indicate a tripling of demand for air travel within the next two decades. New noise reduction technology is critically needed to enable this demand- driven increase in air travel. Additional pressure to reduce airplane noise results from cars, trucks, factories, and other sources of community noise becoming quieter. The demand for reduced community noise impact will continue until public expectations are met.

The Quiet Aircraft Technology program will build upon technology developed in the Advanced Subsonic Technology (AST) Program Noise Reduction Element and in the Base technology development programs to achieve the 10- year Three Pillars noise goal of a factor of two, 10 dB, perceived noise level reduction relative to 1997. Progress in the current planned noise reduction program, the AST and Base programs, is projected to be 5 dB relative to a 1997 baseline.

STRATEGY FOR ACHIEVING GOALS

Through system analysis the rough order of technical performance required to achieve the required 5 EPNdB additional airplane system noise reduction beyond the AST Noise Reduction Program is 4 dB fan noise reduction, 4 dB jet noise reduction, 1 dB core noise reduction, 4 dB airframe system noise reduction, and validation of the 2-dB operational noise benefit identified in the AST Noise Reduction Program. Technologies that will be pursued to achieve these technical objectives include: computational aeroacoustics, active noise control, inflow distortion management, smart materials, embedded sensors, morphing/ smart structures, multidisciplinary component optimization, micro- blowing, adaptive liners, propulsion airframe integration, airplane system optimization, unsteady flow/ turbulence control, real- time minimal noise operations, and accurate single event prediction under realistic weather conditions.

The Quiet Aircraft Technology program will develop and validate technology in the laboratory for an additional 5 Effective Perceived Noise Level decibels (5 EPNdB) community noise impact reduction. This 5 dB consists of both engine and airframe source noise reduction, and advanced operations to reduce community noise impact. Substantial cost sharing with industry would be required to take the developed technology beyond the planned technology readiness level (TRL) (laboratory validation) to full-scale noise-component-reduction concept validation. Achievement of the 10- year National Noise Reduction goal will enable the projected growth in air travel while offering the potential to reduce community noise impact.

SCHEDULE AND OUTPUTS

Demonstrate technologies to reduce community noise impact Plan: September 2000	Demonstrate separate flow jet noise reduction nozzles in flight Demonstrate advanced flight operations to reduce community noise impact Demonstrate advanced active control for GA interior noise
Discovery and initial assessment of concepts to achieve 3 dB airplane system noise reduction Plan: September 2001	Initial assessment of concepts to reduce airframe system noise 4 dB Initial assessment of concepts to reduce engine system noise 4 dB
Identify community noise impact reduction technology required to meet the 10-year, 10-db Enterprise Goal Plan: March 2002	Identify advanced concepts for airframe system noise reduction to be developed in QAT Define requirements for advanced noise abatement flight profiles Identify advanced concepts for engine system noise reduction to be developed in QAT
Initial version of improved aircraft systems noise prediction code delivered for NASA Plan: September 2002	Develop improved aircraft system noise prediction model accounting for placement of noise sources on non-conventional aircraft platforms, account for acoustic interactions between noise sources and platform and be user-friendlier.

ACCOMPLISHMENTS AND PLANS

In FY 2000 static engine tests were conducted on a Pratt & Whitney 4098 to demonstrate engine system noise reduction including both source noise reduction and advanced nacelle concepts. In these tests, an advanced "sugar scoop" inlet configuration and optimized inlet liner treatment validated a 2dB engine system noise reduction. A flight demonstration of a jet noise-reducing advanced engine exhaust nozzle has been slipped until March 2001 because of delays in negotiating industry participation. Advanced flight operations to reduce community noise impact (as much as 10dB on approach) were demonstrated in a flight test program. An improved semi-empirical airframe noise prediction code was completed. An innovative high lift concept demonstrating low noise and high aerodynamic performance was tested at model scale in the NASA-Langley Low Turbulence Pressure Tunnel and a detailed Boeing 777 landing gear was tested in the NASA-Ames 7x10 wind tunnel. Both these tests validated component contributions toward achieving the 4dB-airframe system noise reduction goal. A structural/ acoustic optimized passive/active noise control system was flight tested in a General Aviation airplane and identified the windshield as a major transmission path for interior noise. A series of system studies was conducted to assess component noise reduction concepts required to meet the Enterprise 10- year, 10-dB noise impact reduction goal. In conjunction with the system studies an assessment is being made (and will conclude in the first quarter of FY01) of the developed noise reduction technologies to date. This assessment will involve projecting model scale results to full- scale applications. In conjunction with the FAA, a flight test was conducted at NASA-Wallops to investigate airframe-shielding effects on perceived engine noise for wing- and aft-mounted engine configurations. These data will be used to improve the accuracy of community noise impact models, which is of particular interest to the FAA in formulating response to increased demands for regulatory stringency.

Plans in FY 2001 include the verification of technologies to reduce airframe noise 4 dB on a 26% model of a Boeing 777 in the NASA-Ames 40x80 wind tunnel, conducted under the Noise Reduction Element of the AVST Base technology program. This data will also be used for noise source prioritization in the QAT program. An active noise control system for fan tones will be demonstrated in a static engine test of a Pratt & Whitney 4098 engine. A flight demonstration of several engine system noise-reducing concepts (a variable area nozzle, "sugar scoop" inlet and a jet noise-reducing advanced engine exhaust nozzle) will be conducted on a Lear and Falcon jets. This data will also be used for a new mathematical model and prediction code for airframe shielding of engine noise. Jet noise-reducing engine exhaust nozzles and modeling of jet noise will be further developed. A test of active interior noise reduction concepts will be conducted. Improved interior noise measurement techniques will be developed. Results of the detailed system studies performed in FY00 will be used to investigate and initially define identified noise reduction concepts to achieve the 10- year, 10-dB community noise impact reduction goal. Unconventional aircraft configuration concepts will be reviewed and new concepts will be developed, including modifications of existing unconventional concepts. Concepts that show promise for substantial noise reduction (progress toward the enterprise 20-dB goal) with reasonable prospect of addressing performance issues will be selected for further study. Tools to model actual airport operations (e.g. de-rated take-off thrust and step-down approach trajectories) and actual atmospheric absorption characteristics (e.g. temperature and humidity) will be developed, thus enabling improved airport noise prediction. Noise abatement flight profiles and aircraft operational characteristics will be analyzed to generate operational and automation requirements enabling the design of guidance algorithms and airborne tools.

Plans for FY 2002 include the development of propulsion-airframe aeroacoustics as a systems approach to aircraft noise reduction. A physical description of key noise generating effects due to the engine nacelle pylon geometry and engine exhaust nozzle interaction with the airframe will be developed through noise and flow experiments and CFD analysis. The sensitivity of noise levels to a range of refractive atmospheric characteristics (e.g. wind and temperature gradients) will be determined in order to improve the accuracy of community noise impact models. Current models do not model the difference between upwind and downwind-perceived noise although those differences have been measured to be 5-10dB. Develop a new aircraft system noise prediction model that will account for the placement/movement of individual noise sources on non-conventional aircraft platforms, account for acoustic interactions between the noise sources and platform and be user-friendlier. Initial computer simulations will be developed for the required coordination between the air traffic management system and aircraft on-board systems to achieve consistent low noise operations in a wide range of airspace. Source diagnostics tests will be completed which will give engine component designer's insight into the fundamental physics of the mechanisms that generate broadband fan noise. The data generated by these tests will be used to improve the computational algorithms used in computer codes to predict engine noise. The design of an advanced concept for reduced jet noise will be initiated for testing at laboratory scale later in the QAT program.

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE LAUNCH INITIAITIVE

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Systems Engineering & Requirements Definition	-----	49,890	50,000
RLV Competition & Risk Reduction	-----	94,791	287,000
NASA-Unique Systems	-----	41,708	78,800
Alternative Access	-----	39,912	34,200
Future-X/ Pathfinder *	-----	45,200	25,000
2nd Generation RLV	-----	271,501	475,000
X-33	84,600	-----	-----
X-34	64,300	17,861	-----
Future X/Pathfinder *	34,500	-----	-----
Space Launch Initiative	183,400	289,362	475,000

* Future X/Pathfinder program remains unchanged and is only reflecting a realignment in FY 2001 to the 2nd Generation RLV Program.

PROGRAM GOALS

Low-cost, reliable space transportation remains the key enabler of a more aggressive civil space program. A central tenet of the National Space Policy has been the transition of routine space activities to the private sector to concentrate NASA resources on high-leverage science research, technology development, and exploration activities. By the 2005 time frame, NASA plans to enable a competition for NASA launch services, including human space flight, using commercially competitive, privately owned and operated, Earth-to-orbit Reusable Launch Vehicles (RLVs). The objective will be to dramatically improve safety while significantly reducing the cost of launch services.

The 2nd Generation RLV program will substantially reduce the technical, programmatic and business risks associated with developing a safe, reliable and affordable 2nd Generation RLV architecture. The program will invest in the technology, design, and advanced development efforts to enable at least two competitive options for the mid-decade competition.

STRATEGY FOR ACHIEVING GOALS

The 2nd Generation RLV Program is divided into five major investment areas: Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction, NASA Unique Systems, Alternate Access to Station (AAS), and the Pathfinder program

The Systems Engineering and Requirements Definition effort is critical to establishing vehicle requirements and guiding investments to ensure viable competing architectures. This activity will combine industry and government capabilities to develop detailed technical and programmatic requirements necessary to link technology and other risk reduction efforts to competing architectures. This effort will place a priority on industry and NASA systems engineering activities that seek compatible architectural solutions between commercial industry and NASA requirements. Of paramount importance is achieving significant improvements in safety, reliability and affordability.

The RLV Competition and Risk Reduction component is designed to allow the U.S. space launch industry to pursue significant technical and economic improvements. These advances must sufficiently reduce the risk in order to enable a competition in the 2005 timeframe. NASA will pursue risk reduction efforts that will enable at least two competing architectures. The investment in 2nd Generation RLV risk reduction will be driven by the collective efforts of industry and the government and will be based on NASA needs and competing industry concepts. The risk reduction activities will include technology investments, advanced development activities and flight demonstrations or experiments. Planning calls for multiple industry awards with sufficient government insight to assure success. Government partnerships will be established to obviate redundant proprietary development paths and maximize government return on investment. The selection of industry and NASA investments will be defined consistent with the results of the Systems Engineering and Requirements Definition activities and will be demonstrated (e.g., ground, flight, scale) in the most efficient and cost-effective manner.

The third program element is concentrated on developing and demonstrating the designs, technologies and systems level-integration issues associated with NASA-unique transportation elements and systems. This element will address the additional systems (e.g. crew transport vehicle, cargo carriers, rendezvous and docking systems) necessary to meet unique NASA mission requirements (e.g. Space Station crew transport, cargo return, emergency rescue and return, satellite launch) using commercial launch vehicles. The content of this program element will be defined through the systems engineering and requirements definition process and will be concurrent with the RLV Competition and Risk Reduction activities. NASA will seek the development of unique assets that could be operated in conjunction with multiple commercially provided RLV assets. This program element will consist of contracted efforts in combination with government design, development and integration activities. Solicitations for industry involvement are being conducted in parallel with the RLV Competition and Risk Reduction solicitations.

The fourth program element, Alternate Access to Station, seeks to take advantage of all potential sources of access to space on U.S. launch systems to meet the Agency's requirements. This element supports use of existing and emergent commercial launch vehicles that could launch NASA science payloads and potentially service Space Station requirements and includes necessary risk reduction activities to meet NASA's requirements. NASA will use the Next Generation Launch Services (NGLS), Small Expendable Launch Vehicle Service (SELVS), and NASA Launch Services (NLS) acquisition path as a means to develop contractual relationships with multiple emerging and existing U.S. vendors to meet this objective. These contracts will be for fixed-price services for indefinite delivery indefinite quantity launch contracts

The Pathfinder program was a separate focused activity in prior years, but has now been consolidated within the 2nd Generation RLV program, in keeping with the common objectives of both activities. The objective of the Pathfinder program is to flight-demonstrate advanced space transportation technologies through the use of flight experiments and experimental vehicles, in support of the goal of dramatically reducing the cost of access to space. The Pathfinder Program utilizes innovative, streamlined and efficient management practices to accomplish high-quality demonstrations of technologies with high payoff potential. The demonstrations and experiments will be conducted in a fashion that will promote the technology objectives to the fullest extent possible while maintaining sound engineering judgment.

The Pathfinder Program currently includes the development and operation of the X-37 experimental vehicle as well as a number of flight experiments. These projects were begun prior to the 2nd Generation RLV program activities and, therefore, the technologies being addressed may not completely align with those required by the 2nd Generation Program. However, through close coordination, these issues are being addressed, and all future activities selected in the Pathfinder Program will be explicitly linked to the 2nd Generation RLV program requirements.

The X-37 Space Plane is a flying testbed, a modular demonstrator vehicle that will be the first experimental X-vehicle to be flown in both orbital and reentry environments. This project is being worked under a cooperative agreement with the Boeing Co. of Seal Beach, CA. The DoD has provided additional funds for a number of technologies of interest to them.

Currently, the X-37 is slated to fly two missions on the Space Shuttle, beginning in 2003. However, results from the Second Generation Program's NRA8-30 procurement could influence not only these plans, but also future plans for the X-37.

In addition to the X-37, the Pathfinder Program has a number of additional flight experiments. These experiments will conclude in 2001 and include:

- A Hall-effect Solar Electric Thruster system flight demonstration of new onboard in-space propulsion technologies;
- An experiment to demonstrate ultra-high temperature ceramics for reusable, sharp hypersonic leading edges;
- An experiment to demonstrate advanced in-space propulsion technologies using an electrodynamic tether.

SCHEDULE AND OUTPUTS

Receive Industry Proposals Plan: October 2000 Actual: December 2000	Received Industry proposals for evaluation on Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction and NASA Unique Systems elements within the 2nd Generation RLV program

Contract award Plan: January 2001 Revised: April 2001	Award multiple industry contracts for Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction and NASA Unique Systems elements within the 2nd Generation RLV program
Initial Architecture Review Plan: February 2002	Initial review of competitive 2nd Generation launch architectures, vis-à-vis progress to that point in Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction and NASA Unique Systems elements. This review is required prior to the next stage of the program, which will include a competitive down-selection focused on funding advanced development activities required to bring at least 2 viable concepts to readiness for the final competitive selection in the 2005 timeframe.
X-37 Roll out Plan: September 2001	X-37 Roll out
X-37 Atmospheric Drop test (unpowered) Plan: January 2002	Unpowered approach and landing tests of the X-37 vehicle.
X-37 First Orbital Flight Plan: September 2002 Revised: June 2003	Delayed due to Shuttle Manifesting. Revised date reflects earliest possible accommodation on the Shuttle, with the actual flight date depending on Shuttle availability.
ProSEDS Complete Plan: December 2000 Revised: August 2001	Device will deploy a 5-kilometer (km) bare wire tether coupled to a 10-km nonconducting tether. Earth's magnetic field will accelerate the wire and rise / lower orbit of a Delta II second stage. To be flown as a secondary payload on Delta II upper stage in August 2001.

ACCOMPLISHMENTS AND PLANS

In FY 2001, the 2nd Generation RLV Program solicited industry in the three major areas of Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction and NASA Unique Systems. Industry responded to NASA in December 2000 with proposals consistent with the program objectives. Multiple contract awards are planned for April 2001. NASA will pursue risk reduction efforts that will enable at least two competing architectures. NASA centers will contribute to the effort according to their areas of expertise and in accordance with an overall integrated industry/NASA approach. The competing concepts must address NASA requirements while optimizing the convergence with commercial opportunities. Industry and government partnerships will be established to assure that the ownership and availability of technological advances will be with the implementing contractors.

A requirements/concepts study of potential Alternate Access to Station (AAS) responses was undertaken. These studies addressed a light payload, rapid response version and an augmentation heavy payload version. Results assessment of the AAS study by an Inter-center team (MSFC, LaRC, KSC, and JSC) are now in the final stage. AAS is currently involved in the 2nd Generation evaluation effort (January/February 2001) to determine if synergism opportunities exist. The next phase of the AAS effort is anticipated to be the demonstration of technologies required for autonomous rendezvous proximity operation in the orbital environment.

In FY2001, approach and landing tests of the X-40A will be completed and X-37-Shuttle integration analyses will continue. Trade studies for alternate launch platforms such as an Expendable Launch Vehicle (ELV) will also be initiated. Fabrication, assembly and integration of the X-37 will be completed and the X-37 will be rolled out and pre-flight ground tests will begin.

In FY 2001, launch of the ProSEDS experiment will occur. Data analysis on the material from the SHARP-B2 experiment will be completed and a final report will be generated.

In FY 2002, the 2nd Generation RLV program will complete the initial review of competitive launch architectures, vis-à-vis progress to that point in Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction and NASA Unique Systems elements. This review is required prior to the next stage of the program, which will include a competitive down-selection focused on funding advanced development activities required to bring at least 2 viable concepts to readiness for the final competitive selection in the 2005 timeframe.

In FY 2002, approach and landing test flights of the X-37 will be conducted and preparations for the first Shuttle or ELV flight will begin.

BASIS OF FY 2002 FUNDING REQUIREMENT

X-33

	FY2000	FY2001	FY2002
	(Thousands of Dollars)		
X-33	84,600	-----	-----

PROGRAM GOALS

The X-33 objective is to demonstrate technologies and operations concepts with the goal of reducing space transportation costs to one tenth of their current level.

STRATEGY FOR ACHIEVING GOALS

NASA utilized an innovative management strategy for the X-33 program, based on industry-led cooperative agreements. In following this management strategy, the participants did not play traditional roles, with government overseeing and directing the work of the industry contractors. Instead, government participants acted as partners and subcontractors, performing tasks for industry because the government-industry team believed that these government team members offered the most effective means to accomplish certain program objectivesThe industry-led cooperative arrangement allowed a much leaner management structure, lowered program overhead costs, and increased management efficiency.

The X-33 program Phase II selection was made in July 1996 based on specific programmatic, business planning, and technical criteria. NASA selected the Lockheed Martin Skunk Works to lead an industry team to develop and flight test the X-33.

The X-33 has been an integrated technology effort to flight-demonstrate key technologies required for the next generation of reusable launch vehicles (RLV), and deliver advancements in: 1) ground and flight operations techniques that will substantially reduce operations costs for an RLV; 2) lighter, reusable conformal cryogenic tanks; 3) lightweight, low-cost composite structures; 4) advanced Thermal Protection Systems to reduce maintenance; 5) aerospike engine propulsion and vehicle integration; and, 6) application of New Millennium microelectronics for vastly improved reliability and vehicle health management.

SCHEDULE AND OUTPUTS

X-33 Thermal Protection System (TPS) Delivery Plan: May 2000 Actual: May 2000	Delivery of complete Thermal Protection System for X-33 flight demonstrator. Manufacturing process revised, to improve industry's ability to produce. The X-33 program will come to completion when the cooperative agreement between NASA and Lockheed Martin expires on March 31, 2001. The X-33 program was not selected for additional funding in the 2nd Generation NRA8-30 procurement as NASA determined that the benefits to be derived from continuing the program did not warrant additional government investment.
X-33 Vehicle to Roll out Plan: January 2000 Deleted	X-33 flight demonstrator vehicle rollout enabling final checkout. The X-33 program will come to completion when the cooperative agreement between NASA and Lockheed Martin expires on March 31, 2001. The X-33 program was not selected for additional funding in the 2nd Generation NRA8-30 procurement as NASA determined that the benefits to be derived from continuing the program did not warrant additional government investment.
X-33 First Flight Plan: July 2000 Deleted	The flight test program, based at Edwards Air Force Base, was to fly at speeds greater than Mach 13. The X-33 program will come to completion when the cooperative agreement between NASA and Lockheed Martin expires on March 31, 2001. The X-33 program was not selected for additional funding in the 2nd Generation NRA8-30 procurement as NASA determined that the benefits to be derived from continuing the program did not warrant additional government investment.

ACCOMPLISHMENTS AND PLANS

In FY 2000 the composite hydrogen-tank failure investigation team released its findings that unanticipated micro cracking of the tank lobe's inner skins at cryogenic temperatures, allowing liquid hydrogen leakage, was the root cause of the failure. The design of the aluminum replacement tanks was essentially completed and the long-lead manufacturing needs initiated. Flight and simulation software installation in the Integrated Test Facility at the Dryden Flight Research Center continued for verification and validation. In addition, the linear aerospike single-engine testing at the Stennis Space Center was successfully completed, demonstrating the operational ranges of the engine systems including throttle capability for required for vehicle control. Flight engines 2 & 3 were mated in their flight configuration and installed in the Stennis Center's A1 test stand for dual-engine testing. Vehicle assembly and check out continued at a slowed pace with work-arounds due to the absence of the hydrogen tanks.

In September 2000, NASA and Lockheed Martin agreed on a path forward for the X-33 program. Based on that agreement, the focus of the program was concentrated in two areas: completing the design and beginning the production of the liquid hydrogen tanks and qualifying the flight engines for the X-33 vehicle. Ninety-five percent of the hardware on the program has been built, tested and delivered to the Palmdale assembly facility. This excludes the two flight engines and the aluminum liquid hydrogen tanks.

The vehicle's two flight engines have been joined in a dual configuration and placed in the test stand for simultaneous firings. Cold flow tests took place in December 2000 and concluded in mid-January 2001. Initial hot-fire ignition tests were successfully completed in February 2001.

Following The Preliminary and Critical Design Reviews, the team at Lockheed Martin Space Systems, Michoud Operations set to the task of building a production "pathfinder" panel to validate feasibility of weight reduction strategies. They began with a piece of aluminum weighing 1 1/2 Tons (2950 lbs.) and reduced the weight to 175 lbs. The unique size and shape of the X-33's liquid hydrogen tanks makes this process significantly more complex than that used on the aluminum liquid oxygen tank already complete and installed on the X-33.

Work continued on the tank design to identify any interface changes that need to be made as a result of the switch to aluminum. Since most of the X-33 vehicle hardware has already been built, the LH2 metal tank is designed to emulate the composite tank as much as practical to minimize the interface changes and program costs.

The X-33 Nose Cap entered the last stages of production and nearing completion. Made of an extremely durable carbon-carbon material with an operating range from minus 250° F to about 3,000° F, it is highly resistant to the fatigue loading that would be experienced during ascent and entry.

The robust metallic thermal protection shield (TPS) is 95 percent complete with 1,224 of the panels delivered The panels are attached using only four bolts, making application and removal much simpler and efficient than current methods. The metallic panels have been proven to withstand temperatures near 1,800 degrees Fahrenheit in a series of wind tunnel and arc-jet tests.

The avionics bay was fully wired and put through a series of on-going systems checks resulting in "powering-on" the forward third of the vehicle. During these checks, the power is brought up incrementally to several systems using flight software, ground power supplies and ground software. To date the X-33 has been successfully "powered-on" more than 75 times.

Manufacturing progress continued with the recent completion of the aft thrust structure which would house the two linear aerospike flight engines, the umbilical connections and the reaction control system thrusters while enclosing and protecting the rear of the vehicle.

The body flaps, which would control pitch of the vehicle in flight, are structurally complete and have been through a series of successful "fit" checks. The canted fins are 75 percent complete, awaiting application of the carbon-carbon thermal protection material on the leading edge of the fins. The vertical fins, which house the rudders, are now 100 percent complete.

The rudder actuators are in final checkout and soon will be installed to fully complete the fins. In concert with the canted fins, the vertical fins would stabilize the X-33 in flight.

The X-33 program will come to completion when the cooperative agreement between NASA and Lockheed Martin expires on March 31, 2001. The X-33 program was not selected for additional funding in the 2nd Generation NRA8-30 procurement, as NASA determined that the benefits to be derived from continuing did not warrant additional government investment.

BASIS OF FY 2002 FUNDING REQUIREMENT

X-34

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
X-34	64,300	17,861	---

PROGRAM GOALS

The X-34 objective is to demonstrate technologies and operations concepts with the goal of reducing space transportation costs to one tenth of their current level. The Pathfinder Program formally managed the X-34 project. This project competed for funds under the 2nd Generation RLV Risk Reduction NRA 8-30 but was not selected. NASA's OAT selected to terminate the project in March 2001.

SCHEDULE AND OUTPUTS

X-34 First Unpowered Flight Plan: April 2000 Deleted	The flight test program will expand in increments to assure success. Additional funding for X-34 risk reduction competed within the SLI evaluation of 2nd Generation RLV NRA 8-30 proposals. The X-34 was not selected for funding under the NRA8-30 as NASA determined that the benefits to be derived from continuing the X-34 program did not warrant additional government investment. The program was cancelled in March 2001.
X-34 First Powered Flight Plan: August 2000 Deleted	The flight program will expand the flight profile with initial, unpowered flights to be followed by powered flights that will reach Mach 8. Additional funding for X-34 risk reduction competed within the SLI evaluation of 2nd Generation RLV NRA 8-30 proposals. The X-34 was not selected for funding under the NRA8-30 as NASA determined that the benefits to be derived from continuing the X-34 program did not warrant additional government investment. The program was cancelled in March 2001.

Delivery of IVHM experiment Plan: June 2001 Revised: Deleted	The Integrated Vehicle Health Monitoring (IVHM) experiment is delivered for installation on X-34 vehicle A-3. Additional funding for X-34 risk reduction competed within the SLI evaluation of 2nd Generation RLV NRA 8-30 proposals. The X-34 was not selected for funding under the NRA8-30 and the program was cancelled in March 2001.

ACCOMPLISHMENTS AND PLANS

In 2000, the X-34 A-1A vehicle assembly was completed and began testing at Dryden Flight Research Center. The vehicle underwent a series of captive-carry flights and high-speed ground tow tests. The X-34 A-2 vehicle assembly is in process and subsystem tests were performed as required. The X-34 A-3 vehicle-airframe fabrication began in 2000 as scheduled.

The main propulsion system for the X-34 vehicle, the MC-1 engine, continued testing including a full-duration firing. To date, the engine has undergone approximately 45 hot-fire tests. The flight engine was delivered to Orbital Sciences Corporation and was integrated with A-2 vehicle.

Approximately ten operational and vehicle technologies embedded in the design and hosted as test articles continue to progress through planned milestones.

In FY2000, the program was thoroughly reviewed by a NASA Risk Evaluation team.

In FY2000, a NASA and Orbital Sciences Corporation review revealed the need to redefine the project scope, budget, and schedule. The redefined project included additional risk reduction hardware and testing that would significantly improve the likelihood of mission success. NASA required that X-34 risk reduction funding should be competed for within the SLI ISTP competitive process.

Additional funding for X-34 risk reduction competed within the SLI evaluation of 2nd Generation RLV NRA 8-30 proposals. The X-34 was not selected for funding under the NRA8-30 and the program was cancelled in March 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

AEROSPACE INSTITUTIONAL SUPPORT

	FY 2000 OPLAN 1/18/01	FY 2001 PLAN 3/1/01	FY 2002 PRES BUDGET
	(Thousands of Dollars)		
Research and Program Management (R&PM)	[649,990]	[722,995]	781,631
Labor	[513,523]	[589,551]	602,775
Travel	[13,156]	[14,965]	16,385
Research Operations Support (ROS)	[123,311]	[118,479]	162,472
Construction of Facilities (CoF) - (Non-Programmatic)	[58,962]	[87,363]	89,607
Institutional Support to Aerospace Technology	**[708,953]**	**[810,359]**	**871,239**

Distribution of Program Amount by Installation			
Johnson Space Center	[3,049]	[3,176]	3,220
Kennedy Space Center	[16,163]	[14,580]	13,863
Marshall Space Flight Center	[88,267]	[95,082]	97,210
Stennis Space Center	[14,861]	[22,285]	14,626
Ames Research Center	[121,010]	[148,403]	152,728
Dryden Flight Research Center	[55,984]	[58,125]	54,277
Langley Research Center	[185,710]	[199,490]	214,184
Glenn Research Center	[141,797]	[178,923]	177,072
Goddard Space Flight Center	[8,871]	[11,447]	11,980
Jet Propulsion Laboratory	[4,875]	[5,837]	8,552
Headquarters	[68,366]	]73,011]	123,527
Total	{708,953}	{810,359}	871,239
Aerospace Technology Full-Time Equivalent (FTE) Workyears	**4345**	**4713**	**4710**

* Numbers in brackets are the prior year totals to reflect a correct representation of the cross-year funding levels.

PROGRAM GOALS

The two primary goals of this budget segment is to:

1. Acquire and maintain a civil service workforce, that reflects the cultural diversity of the Nation and, along with the infrastructure, is sized and skilled consistent with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency for the Aerospace Technology Enterprise.

2. Ensure that the facilities critical to achieving Aerospace Technology Enterprise program goals are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform to requirements and initiatives for the protection of the environment and human health.

RESEARCH AND PROGRAM MANAGEMENT (R&PM): program provides the salaries, other personnel and related costs, travel and the necessary support for all administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 79% of the requested funding. Administrative and other support is approximately 19% of the requests. The remaining 2.0% of the request are required to fund travel necessary to manage NASA and its programs.

CONSTRUCTION OF FACILITIES (CoF): budget line item provides for discrete projects required for components of the basic infrastructure and institutional facilities and almost all are for capital repair. NASA facilities are critical for the Aerospace Technology Enterprise, to sustaining the future of aeronautics and advanced space transportation, which both support military and private industry users. NASA has conducted a thorough review of its facilities infrastructure finding that the deteriorating plant condition warrants an increased repair and renovation rate to avoid safety hazards to personnel, facilities, and mission; and that some dilapidated facilities need to be replaced. Increased investment in facility revitalization is needed to maintain a facility infrastructure that is safe and capable of supporting NASA's missions.

ROLES AND MISSIONS

The detail provided here is for the support of the Aerospace Technology Enterprise institutions - Ames Research Center, Dryden Flight Research Center, Glenn Research Center, Langley Research Center, Marshall Space Flight Center, Stennis Space Center, and Goddard Space Flight Center.

AMES RESEARCH CENTER (ARC)

The Aerospace Technology Enterprise funds approximately 69% of ARC's Institution cost. ARC conducts aeronautics research in ground-based and airborne automation technologies, human factors, and operational methodologies for safe and efficient airspace operations. They provide Agency-wide leadership in conducting research and technology development to enable and foster the intelligent vehicle of the future through the implementation of integrated vehicle health management as a vehicle discipline. They provide high-fidelity flight simulations to support national goals in aviation safety and capacity, as well as vehicle development requirements. They conduct research, spanning computation through flight, for high-performance aircraft, to improve efficiency, affordability, and performance. They are also developing an integrated set of experimental and computational technologies built around an embedded information systems backbone, to provide rapid, accurate vehicle synthesis and testing capabilities.

ARC scientists and technologists conduct research on advanced thermal protection systems and perform arcjet testing to meet national needs for access to space and planetary exploration. Ames is the lead center for information technology efforts in the Space Base program (formerly called Cross-Enterprise Technology). In addition, Ames is the lead center for the Intelligent Systems program, which provides critical, next-generation information technology capabilities for NASA missions and activities.

DRYDEN FLIGHT RESEARCH CENTER (DFRC)

The Aerospace Technology Enterprise funds approximately 75% of DFRC's Institution cost. DFRC develops, manages, and maintains facilities and testbed aircraft to support safe, timely, and cost-effective NASA flight research and to support industry, university, and other government agency flight programs. Dryden FTEs conceive, formulate, and conduct piloted and unpiloted research programs in disciplinary technology, integrated aeronautical systems, and advanced concepts to meet current and future missions throughout subsonic, supersonic, and hypersonic flight regimes. DFRC will also provide flight test support for atmospheric tests of experimental or developmental launch systems, including reusable systems. DFRC's flight research programs are conducted in cooperation with other NASA installations, other government agencies, the aerospace industry, and universities.

GLENN RESEARCH CENTER (GRC)

The Aerospace Technology Enterprise funds approximately 72% of GRC's Institution cost. As the NASA Lead Center for Aeropropulsion, GRC conducts world-class research critical to the Agency Aerospace Technology Enterprise goals of developing and transferring enabling technologies to U.S. industry and other government agencies. The Center's Aeropropulsion programs are essential to achieving National goals to promote economic growth and national security through safe, superior, and environmentally compatible U.S. civil and military aircraft propulsion systems. The Aeropropulsion program at GRC spans subsonic, supersonic, hypersonic, general aviation, high-performance aircraft, as well as access-to-space propulsion systems. The program pursues innovative applications of research in turbomachinery materials, structures, internal fluid mechanics, instrumentation and controls, interdisciplinary technologies, and aircraft icing. GRC has research expertise in world-class facilities critical to ensuring U.S. leadership in aviation. FAA, EPA, and DOD in particular depend on NASA GRC research for advancements in emissions, noise, engine performance and new materials.

As the NASA Center of Excellence in Turbomachinery, GRC expertise is critical to advancing the Agency's goals in our aeronautics and space programs and enables GRC to be a cost-effective resource across multiple Agency programs. Turbomachinery-based areas of expertise include air breathing propulsion and power systems, primary and auxiliary propulsion and power systems, on-board propulsion systems, and rotating machinery for the pumping of fuels/propellants.

LANGLEY RESEARCH CENTER (LaRC)

The Aerospace Technology Enterprise funds approximately 78% of LaRC's Institution cost. The LaRC conducts advanced research in fundamental aerodynamics; high-speed, highly maneuverable aircraft technology; hypersonic propulsion; guidance and controls; acoustics; and structures and materials. They are developing a technology base for improving transport, fighter, general aviation, and commuter aircraft. These LaRC scientists and technologists are conducting an aeronautical research and technology program to study current and future technology requirements and to demonstrate technology applications. They conduct theoretical and experimental research in fluid and flight mechanics to determine aerodynamic flows and complex aircraft motions. They are also conducting research to develop technologies and capabilities that permit the integration of widely distributed science, technology, and engineering teams and that provide advanced tools enabling the teams to create innovative, affordable products rapidly.

LaRC develops innovative new airframe systems to improve safety, reduce emissions and cut noise levels. These new airframe systems technologies will improve environmental compatibility, increase capacity, and reduce cost per seat mile of commercial transport and general aviation aircraft. LaRC technologists conduct control and guidance research programs to advance technology in aircraft guidance and navigation, develop aircraft control systems, improve cockpit systems integration and interfacing techniques, and enhance performance validation and verification methods. LaRC also conducts research in aircraft noise prediction and abatement. LaRC personnel are pioneering the development of new materials, structural concepts, and fabrication technologies to revolutionize the cost, performance, and safety of future aircraft structures while creating radically new aircraft designs. LaRC provides Agency wide leadership and strategically maintains or increases the agency's preeminent position in structures and materials by serving as the NASA Center of Excellence for Structures and Materials.

LaRC scientists and technologists also conduct aeronautics and space research and technology development for advanced aerospace transportation systems, including hypersonic aircraft, missiles, and space access vehicles using airbreathing and rocket propulsion. Specific technology discipline areas of expertise are aerodynamics, aerothermodynamics, structures, materials, hypersonic propulsion, guidance and controls, and systems analysis. They also conduct long-range studies directed at defining the technology requirements for advanced transportation systems and missions. In addition, they develop technology options for realization of practical hypersonic and transatmospheric flight.

MARSHALL SPACE FLIGHT CENTER (MSFC)

The Aerospace Technology Enterprise funds approximately 27% of MSFC's Institution cost. The MSFC is the NASA Lead Center for space transportation systems development. The MSFC FTE's plan, direct, and execute research, technology maturation, advanced design and development, and sustaining engineering for NASA's next-generation space transportation systems. These systems include reusable launch vehicles and other associated transportation systems and subsystems. MSFC will integrate program and project level planning, research, and development to ensure a well-balanced space transportation development program that meets the Agency's aggregate needs in a coordinated and integrated manner. MSFC people will develop technology in vehicle and propulsion systems, advanced manufacturing processes, and materials and structures. The Center will conduct technology efforts, under contract including cooperative agreements, with the U.S. launch vehicle industry, to improve the competitiveness of current systems.

STENNIS SPACE CENTER (SSC)

The Aerospace Technology Enterprise funds approximately 25% of SSC's Institution cost. SSC supports the development of new and innovative propulsion technologies by providing propulsion test capabilities for the Space Launch initiative, including both 2nd Generation and 3rd Generation systems.

GOODDARD SPACE FLIGHT CENTER (GSFC)

The Aerospace Technology Enterprise funds approximately 3% of GSFC's Institution cost. GSFC directs the Wallops Flight Facility which provides institutional and technical support to LaRC, other NASA centers, and commercial users, who conduct flight studies of new approach and landing procedures using the latest in guidance equipment and techniques, pilot information displays, human factors data, and terminal area navigation.

HEADQUARTERS

The Aerospace Technology Enterprise funds approximately 38% of Headquarters' Institution cost. The Enterprise's Institutional Support figure includes an allocation for funding Headquarters activities based on the relative distribution of direct FTE's across the agency. A more complete description can be found in the Mission Support/two Appropriation budget section.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF AEROSPACE TECHNOLOGY — **COMMERCIAL TECHNOLOGY PROGRAMS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Commercial Programs	35,049	43,105	29,800	SAT 4.2-2
Technology Transfer Agents	7,356	8,282	5,800	SAT 4.2-2
Small Business Innovation Research Programs	97,600	111,055	111,300	SAT 4.2-2
Total	140,005	162,442	146,900	
Distribution of Program Amount by Installation				
Johnson Space Center	14,242	15,094	14,196	
Kennedy Space Center	6,392	6,255	6,609	
Marshall Space Flight Center	17,121	16,017	16,504	
Stennis Space Center	5,000	4,714	4,977	
Ames Research Center	15,428	14,569	14,256	
Dryden Flight Research Center	4,200	3,921	4,200	
Langley Research Center	17,741	17,075	18,018	
Glenn Research Center	25,513	28,403	23,395	
Goddard Space Flight Center	29,668	32,398	39,931	
Jet Propulsion Laboratory	2,916	4,790	2,867	
Headquarters	1,784	19,205	1,947	
Total	140,005	162,442	146,900	

BASIS OF FY 2002 FUNDING REQUIREMENT

COMMERCIAL TECHNOLOGY PROGRAM

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Commercial Programs	35,049	43,105	29,800
Baseline Commercial Programs	(29,100)	(28,936)	(29,800)
Special Interest Projects	(5,949)	(14,169)	--
Technology Transfer	7,356	8,282	5,800
Baseline Tech Transfer Agents	(5,800)	(5,787)	(5,800)
Special Interest Projects	(1,556)	(2,495)	--
Small Business Innovative Research Program	97,600	111,055	111,300
Total Commercial Technology Programs	140,005	162,442	146,900

PROGRAM GOALS

NASA's Commercial Technology Program includes Commercial Programs, Technology Transfer Agents and the Small Business Innovative Research (SBIR) Program. NASA's Commercial Technology Program facilitates the transfer of NASA inventions, innovations, discoveries or improvements developed by NASA personnel or in partnership with industry/universities to the private sector for commercial application leading to greater U.S. economic growth and competitiveness.

The goal of Commercial Programs is to share the harvest of NASA's technology programs with the U. S. industrial/scientific community. The goal encompasses the commercialization of technology developed in all the Agency's Enterprises, in the recent past as well as current programs. The NASA Commercial Program mission includes a variety of mechanisms for achieving its goals: partnerships with industry/academia; federal/state/local alliances; emphasis on commercialization in new R&D procurements; electronic commerce; training and education of NASA employees/contractors; employee accountability; and application of performance goals/metrics.

The goal of Technology Transfer Agents is to facilitate the transfer of NASA and other federally sponsored research and technology (and associated capabilities) to the U. S. private sector for commercial application. The purpose of this program goal is to enhance U. S. industrial growth and economic competitiveness.

The goal of NASA's Small Business program is to promote the widest possible award of NASA research contracts to the small business community as well as to promote commercialization of the results of this research by the small business community.

Established by Congress, the SBIR program (which includes NASA's Small Business Technology Transfer (STTR) programs) helps NASA develops innovative technologies by providing competitive research contracts to U.S.-owned small businesses.

STRATEGY FOR ACHIEVING GOALS

Commercial Programs

Commercial Programs introduces a mix of practices/mechanisms, which enable the Agency to more closely align its way of doing business with that of the private sector. The common denominator in these practices is technology partnerships. Technology partnerships are business arrangements among government, industry, and/or academia wherein each party commits resources to the accomplishment of mutually agreed upon objectives and shares the risks and rewards of the endeavor. By working together, NASA and industry can push technologies of joint interest further and faster, while also reducing the costs to both parties.

The success of Commercial Programs is accomplished through:

- An extensive outreach program (technology dissemination and marketing);
- An electronic commerce/information network (via the Internet) that greatly facilitates the transfer of technology and allows very efficient implementation of our technology business contacts and services;
- Training and education of NASA employees to emphasize program relevance to national needs and to facilitate program implementation;
- The use of metrics that address management processes as well as bottom-line results;
- The establishment of productive technology development and application partnerships with industry.

Technology Transfer Agents

Technology Transfer Agents facilitate the transfer/use of NASA and other Federally sponsored research and technology (and associated capabilities) to the U. S. private sector for commercial application to enhance U. S. industrial growth and economic competitiveness. Technology Transfer Agents include funding for the National Technology Transfer Center (NTTC) at Wheeling Jesuit College in West Virginia and the TechLink Center at Montana State University.

In conformance with Congressional direction, NASA has funded the NTTC since 1990. The NTTC serves as a national resource for the transfer and commercialization of federal research and technology. A key, on-going strategy is to align and integrate NTTC operations with the NASA Commercial Technology Programs in support of the NASA Commercial Technology Mission. This strategy provides a foundation upon which the NTTC may fulfill its national role through technology transfer programs funded by other federal agencies and the provision of cost-recovery products and services. Accordingly, NASA has facilitated the involvement of other federal agencies to leverage and extend NTTC capabilities funded by NASA and has enabled the NTTC to implement cost-recovery activities in support of the overall federal technology transfer mission.

The NTTC performs four core roles:

1. Serve as a national gateway for federal technology transfer and commercialization, assisting U. S. industry to locate and access NASA and other federally-sponsored technology resources and sources of technical/business assistance;
2. Assess NASA and other federal technologies for commercial potential, and facilitate partnerships for technology commercialization;
3. Develop and deliver professional-level training in technology transfer and commercialization for NASA, federal agencies and other public and private sector audiences; and
4. Promote U. S. industry awareness and utilization of NASA and other federally sponsored research and technology resources available for commercial purpose.

Also in conformance with Congressional direction, NASA has established a cooperative agreement with Montana State University to establish and operate the TechLink Center, a rural states technology transfer and commercialization center. The mission of the TechLink Center is to assist firms and targeted industries in Montana, North Dakota, South Dakota, Wyoming and Idaho, to utilize and commercialize technologies from NASA, federal laboratories and universities. Small Business Innovative Research Program
The Small Business Innovation Research (SBIR) program helps NASA develop innovative technologies by providing competitive research contracts to U.S.-owned small businesses. The program is structured in three phases. Phase I is the opportunity to establish the feasibility, technical merit, and NASA mission need of a proposed innovation. Selected competitively, Phase I contracts have a term of six months and currently do not exceed $70,000. Phase II is the major R&D effort in SBIR. The most promising Phase I projects are selected to receive contracts worth up to $600,000 and have a term of up to two years. Approximately 50 percent of Phase I projects are approved for Phase II. Phase III is the completion of the development of a product or process to make it marketable. SBIR program funding cannot be used to support the Phase III program. Private sector investment and sales of products and services based on the SBIR technology is the usual source of Phase III funding.

SCHEDULES & OUTPUTS

Commercial Programs

Increase commercial partnerships Plan: December 1999 Actual: December 1999	Increase percentage of NASA R&D invested in commercial partnerships with a goal of achieving 15-20 percent.
Deploy Quarterly automated metric reporting system Plan: June 2000 Actual: February 2000	Complete deployment of quarterly automated metrics reporting module at all NASA centers.

Deploy Quarterly automated metric reporting system Plan: September 2000 Actual: September 2000	Complete deployment of electronic new technology reporting (eNTRe) at all NASA centers.
Update commercial assessment of NASA activities Plan: December 2000 Revised: September 2001	Update commercial assessment of NASA activities.
Increase partnership percent to goals 20 percent Plan: December 2000 Revised: September 2001	Increase partnership percent to goals 20 percent
Incorporate facilities as integral part of commercial assessment Plan: December 2000 Revised: September 2001	Incorporate NASA facilities as integral part of commercial assessment process.
Assess NASA technology for commercial application Plan: September 2002	Assess 100% of NASA technology for commercial application.
Maintain commercial partnership goals at 20 percent Plan: September 2002	Maintain commercial partnership goals at 20 percent.
Expand training program for NASA R&D program managers Plan: September 2002	Expand training program for NASA R&D program managers.

Technology Transfer Agents

Facilitate/broker 7 technology partnerships involving regional firms/organizations and NASA technology, research/technology objectives or capabilities. Plan: May 2000 Deleted	Facilitate/broker 7 technology partnerships involving regional firms/organizations and NASA technology, research/technology objectives or capabilities. [Note: task had been inappropriately included within Technology Transfer Agents; technology partnerships – by definition -- are included within the Commercial Technology baseline program]
Deliver 10 Commercial Technology training courses Plan: September 2000 Actual: September 2000	Deliver, through a partnership between the NTTC and NASA, 10 Commercial Technology training courses in FY 2000. [Note: the goal was not only accomplished as planned but 2 additional training courses were also delivered.]
Service a minimum of 16,000 inquiries and produce at least 750 qualified referrals Plan: September 2000 Actual: September 2000	Service a minimum of 16,000 inquiries and produce at least 750 qualified referrals for NASA technologies. [Note: highly qualified leads totaling 309 were derived through vigorous screening to determine partnership potential which is more beneficial to the Centers than a broad-band referral.]
Complete 25 in-depth commercialization potential assessments of technologies Plan: September 2000 Actual: September 2000	Complete 25 in-depth commercialization potential assessments of NASA technologies. [Note: the NTTC completed 36 screenings of NASA technologies and determined that 15 technologies were the most promising in the commercial environment.]
Facilitate the formation of licensing/partnership agreements for 10 NASA technologies Plan: September 2000 Actual: September 2000	Facilitate the formation of licensing/partnership agreements for 10 NASA technologies. [Note: although our goal was to establish 10 partnership agreements, which take approximately 2 years to negotiate and complete, 4 partnership agreements were completed.]
Deliver 14 Commercial Technology training courses in FY 2001 Plan: September 2001	Deliver, through a partnership between the NTTC and NASA, 14 Commercial Technology training courses in FY 2001.

Service industry technology inquiries and produce 200-300 highly qualified technologies leads Plan: September 2001	Service industry technology inquiries and produce 200-300* highly qualified leads for NASA technologies. [*Note: based on achievement in FY2000 and refocused screening efforts, 750 referrals have been revised to 200-300 highly qualified leads.)
Review 30 technologies and complete 9 in-depth potential assessments in FY 2001 Plan: September 2001	Review 30 NASA technologies and complete 9 in-depth commercialization potential assessments.
Formulate licensing/partnership agreements for 5-10 technologies in FY 2001 Plan: September 2001	Facilitate the formation of licensing/partnership agreements for 5-10* NASA technologies. [*Note: based on FY2000's accomplishment of 4 partnerships, using an estimate of 5-10 partnerships is more realistic.]
Deliver 14 Commercial Technology training courses in FY 2002 Plan: September 2002	Deliver, through a partnership between the NTTC and NASA, 14 Commercial Technology training courses in FY 2002.
Produce 200-300 highly qualified technologies leads in FY 2002 Plan: September 2002	Service industry technology inquiries and produce 200-300 highly qualified leads for NASA technologies in FY 2002.
Review 30 technologies and complete 9 in-depth potential assessments in FY 2002 Plan: September 2002	Review 30 NASA technologies and complete 9 in-depth commercialization potential assessments.
Formulate licensing/partnership agreements for 5-10 technologies in FY 2002 Plan: September 2002	Facilitate the formation of licensing/partnership agreements for 5-10 NASA technologies.

Small Business Innovative Research Program

Select and announce SBIR PY 1999 Phase I awards Plan: October 1999 Actual: October 1999	Select and announce SBIR PY 1999 Phase I awards.
Complete development and issue the PY 2000 SBIR Phase I solicitation Plan: April 2000 Actual: April 2000	Complete development and issue the PY 2000 SBIR Phase I solicitation.
Electronic submission of proposals via the internet at the close of PY2000 Phase I solicitation Plan: August 2000 Actual: July 2000	Electronic submission of proposals via the internet at the close of PY2000 Phase I solicitation.
Select and announce SBIR PY 1999 Phase II awards Plan: August 2000 Actual: September 2000	Select and announce SBIR PY 1999 Phase II awards.
Select and announce SBIR PY 2000 Phase I awards Plan: October 2000 Actual: December 2000	Select and announce SBIR PY 2000 Phase I awards.
Complete development and issue the PY 2001 SBIR Phase I solicitation Plan: April 2001	Complete development and issue the PY 2001 SBIR Phase I solicitation.
Electronic submission of proposals via the Internet at the close of PY2001 Phase I solicitation Plan: August 2001	Electronic submission of proposals via the Internet at the close of PY2001 Phase I solicitation.

Select and announce SBIR PY 2000 Phase II awards Plan: August 2001	Select and announce SBIR PY 2000 Phase II awards.
Select and announce SBIR PY2001 Phase I awards Plan: October 2001	Select and announce SBIR PY2001 Phase I awards
Complete development of and issue the PY 2002 SBIR Phase I solicitation Plan: June 2002	Complete development of and issue the PY 2002 SBIR Phase I solicitation.
Electronic submission of proposals via the internet at the close of PY2002 Phase I solicitation Plan: August 2002	Electronic submission of proposals via the internet at the close of PY2002 Phase I solicitation.
Select and announce SBIR PY 2001 Phase II awards Plan: August 2002	Select and announce SBIR PY 2001 Phase II awards.

ACCOMPLISHMENTS AND PLANS

Commercial Programs

In FY 2000, the emphasis of Commercial Programs was on showing steady improvement toward increasing the percentage of the NASA R&D budget in commercial partnerships. Also in FY 2000, deployment of electronic new technology reporting (eNTRe), which provides innovators and researchers a secure desktop tool for identifying and reporting new technologies and innovations, was completed. In conformance with FY 2000 Congressional direction pertaining to appropriation action, the following was completed: 1) The continuation of the Garrett Morgan initiative in Ohio to assist the establishment of Women and Minority owned businesses; and 2) an augmentation of the NTTC activity.

In FY 2000, commercial partnerships with industry achieved a level of about 19% and the technology and partnership database was refined, updating it to include new Agency contracting efforts and describe new technologies that were made public via the electronic network. NASA will continue to improve the utilization of the Internet as an electronic marketplace for NASA technology assets, facilitating technology transfer and commercialization opportunities between U.S. industry and NASA. We expanded training opportunities focused on commercial technology strategy and its implementation within NASA's management training program. In FY2000, we initiated and have successfully established Strategic Technology Development Partnerships with the advanced materials and sensors/instruments industries. These partnerships meet the goal of establishing joint-sponsored R&D projects with industry to share risk and cost in the development of new technologies critical to NASA missions.

In FY2001, NASA plans to continue the goal of 15-20 percent of the NASA R&D budget in commercial partnerships with industry. NASA plans to have a fully operational Commercial Technology Training syllabus and curriculum accessible by NASA employees and deliver, through partnership between the NTTC and NASA, 14 commercial technology-training courses. The Commercial Program plans to expand services offered to each of the four NASA Enterprises and target a new non-aerospace industry sector – the medical devices industry. This furthers the goal of establishing joint-sponsored R&D projects with industry that will share risk and cost in the development of new technologies critical to NASA missions. In addition, NASA expects to introduce a new model for technology commercialization that leverages the high tech investment community for partnerships with NASA and the high tech business community.

The following Congressional programmatic activities will be performed in FY 2001:

1) Expanded Space Alliance outreach program in the states of NY, NM, TX, FL;
2) Continuation of the NASA-Illinois Technology Commercialization Center;
3) Extension of the Eye-Tracking technology development;
4) Continuation of the Earth Alert program;
5) Augmentation of the NTTC activities;
6) Initiation of the Rural Enterprise Inc program; and
7) Continuation of the Montana State TechLink center.

In FY2002, we plan to continue the percent of technology in partnership with industry in the 15-20 percent range, but will consider alternative metrics. NASA plans to expand the new training opportunities for NASA employees by delivering, through partnership between the NTTC and NASA, 14 commercial technology-training courses at NASA centers and the NTTC. In addition, we plan to initiate the fourth strategic partnership initiative with a non-aerospace industry sector.

Technology Transfer Agents

The National Technology Transfer Center (NTTC) is a national resource for NASA and federal technology transfer and commercialization. The NTTC performed as a national gateway for NASA technology, servicing inquiries and producing qualified leads leading to effective technology partnerships.

In FY 2000, 12 technology commercialization training sessions were delivered to NASA personnel to implement required skills and best practices throughout NASA, including 2 sessions on Intellectual Property, Technology Licensing and Commercializing Technologies. The NTTC performs as a national gateway for NASA technology, servicing thousands of inquires for NASA technology. In FY 2000, the NTTC produced 309 highly qualified referrals to NASA centers for technology transfer/commercialization partnerships. The 309 qualified leads versus the 750 planned referrals were due to more vigorous lead screening to yield higher potential opportunities. The refocused screening process allows the NASA centers to focus more on completing a partnership [as opposed to contacting “casually interested” referrals. While the NTTC planned to complete 25 in-depth commercialization potential assessments of NASA technologies, a total of 36 in-depth screenings of NASA technologies were completed and commercialization assessments were provided for the 15 most promising technologies. The NTTC also facilitated partnership formation with private industry that led to 4 partnership agreements for NASA technologies. Partnership agreements take approximately 2 years to negotiate and complete. Although we estimated completing 10 partnership agreements, only 4 partnership agreements materialized. The NTTC proposed facilitating/brokering 7 technology partnerships involving regional firms/organizations as an FY2000 goal; however, NASA deleted this element from the NTTC’s scope of work because this task is already included within the Commercial Technology baseline program.

Also in FY 2000, TechLink brokered 16 technology partnerships involving northwestern U.S. companies and NASA centers or NASA technology. These partnerships included 8 different NASA centers as well as companies in 5 Western states. In addition, TechLink facilitated 12 partnerships involving regional companies and the Department of Defense and other federal agencies, for a total of 28 partnerships (versus the goal of 15).

In FY 2001, the NTTC will deliver 14 technology commercialization training course sessions to NASA personnel; will develop two new training courses on “Software Release Authority” and “Creating a Commercialization Plan”; and will provide 2 internet based training courses for NASA personnel. The NTTC will continue to perform as a national gateway for NASA technology. The NTTC will assess approximately 2000 leads from industry in FY 2001 and produce 200-300 highly qualified referrals to NASA centers for technology transfer/commercialization partnerships. The lower range of 200-300 qualified leads is adopted for FY 2001 because the quality of leads (facilitated by the NTTC and referred to NASA) has increased greatly in the last fiscal year due to more stringent referral criteria. Qualified leads received by NASA represent companies that have more than just a passing interest in working with NASA. They represent only those companies that have a concrete interest in pursuing a partnership with NASA to commercialize its technologies. Based on industry practice, we expect 10-15% of all leads generated to be qualified. The NTTC will complete 30 technical reviews of NASA technologies, perform 5-10 commercialization strategies, and assist the formation of licensing/partnership agreements for about 5-10 NASA technologies. TechLink plans to facilitate at least 20 NASA-related technology partnerships, including Space Act and licensing agreements. In addition, it will facilitate another 18 technology partnerships between companies in its region and DoD and other federal research centers.

In FY 2002, the NTTC will continue to perform as a national gateway for NASA technology, providing about 200-300 highly qualified referrals to NASA centers for technology transfer/commercialization. The NTTC will facilitate 5-10 partnerships that will be either completed or in final discussion with the NASA Centers. In FY2002, the NTTC will deliver approximately 14 commercial technology training course sessions to NASA personnel; will develop a new training course on Small Business Innovation Research; will develop multimedia training course on NASA TechTracS; and will continue delivery of internet based training courses for NASA personnel. In FY 2002, TechLink goals for FY 2002 include at least 22 NASA-related technology partnerships and 20 additional technology partnerships with DoD and other federal agencies.

Small Business Innovative Research Program

In accordance with the Small Business Innovation Development Act of 1982, the actual SBIR funding level for the Agency is determined based on the results of a detailed analysis of the actual obligations for the most recent fiscal year that data is available. For FY 2000 and FY 2001, the funding levels are based on actual data. For FY 2002, the funding level shown for SBIR is a placeholder that is used for planning purposes only. In early FY 2002, the Office of the Comptroller will perform a detailed assessment on the Agency's most recent actual data. The results of this assessment will be used to validate that the actual SBIR funding level to the budgeted amount. If the budgeted amount is not valid a change will be reflected in the Agency's initial operating plan to Congress.

In FY 2000, the NASA SBIR program continues to contribute to the U. S. economy by fostering the establishment and growth of over 1,400 small, high technology businesses. The NASA SBIR commercialization survey was be extended to include commercial results for Phase II's awarded by NASA in 1995. More than 548 products and services at least partially based on NASA SBIR technology have generated revenues in non-government markets. In total NASA SBIR Phase II firms have produced Phase III agreements generating over $2 million per firm in revenues. In FY 2000, approximately 120 SBIR Program Year (PY) 1999 Phase I research proposals were selected for Phase II award September 6, 2000. This date was revised due to a program administrative delay, from the planned date of August 1999. The selected projects total approximately $72 million and were conducted by 97 small, high technology firms located in 27 states.

In FY 2001 the NASA SBIR PY2000 Solicitation resulted in selection of 280 research proposals for Phase I award, and was completed in December. Because of the delay in SBIR Reauthorization authority, that was signed on December 22nd. The award announcement date for SBIR PY2000 Phase I was delayed. Consequently, the associated Phase II award date has been revised. NASA achieved a 99 percent fully automated process, from proposal receipt to final report submission, and will achieve 100% pending adoption and use of federal & NASA electronic signature standards. The SBIR PY 2000 Phase II awards will be selected by August 2001. The information from the review/survey is being used to determine likelihood of commercial intent and, therefore, increase the effectiveness of the program's commercialization efforts. Finally, the process of correlating sub-topics with specific NASA mission applications and institutional needs continues to be a focus for strategic planning activities, with the intent to more closely tie the SBIR/STTR programs with each other as well as with both the mission needs of each NASA Enterprise and the institutional core of every NASA center.

In FY 2002, NASA's PY 2001 SBIR/STTR (Small Business Technology Transfer) solicitation will include both the SBIR and STTR subtopics. The descriptions will be developed, as before, by various NASA installations to include current and anticipated Agency program needs and institutional priorities. NASA typically receives over 2,000 proposals for the SBIR solicitation alone. For this combined solicitation, proposals will be evaluated by the NASA field centers for scientific and technical merit, key staff qualifications, soundness of the work plan, and plans for commercial application. NASA Headquarters (HQ) program offices will provide additional assessment regarding commercial, program balance, and critical Agency requirements. Selections will continue to be made by NASA HQ, based upon these recommendations, and other considerations. NASA will continue to expand the utilization of the Internet in the administration and management of these programs. NASA also provides information for public access via a bulletin board service and other Internet information servers.

Several other program initiatives continued to strengthen NASA's implementation of these small business programs. External evaluation of each proposal's ultimate commercial potential remains a fundamental part of the selection process. In addition, the continued comprehensive survey of past SBIR projects' Phase III commercialization and/or mission application remains vital to yielding valuable data about the program outcomes. In FY 2002, the commercialization survey will be extended to include commercial results for Phase II's awarded by NASA in 1996 and 1997. The PY 2001 SBIR Phase I awards will be selected by October 2001. The PY2001 Phase II awards will be selected by August 2002.

SCIENCE, AERONAUTICS, AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT **MISSION COMMUNICATIONS SERVICES**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Ground Networks	162,000	--	--	SAT 5-4
Mission Control and Data Systems	233,800	--	--	SAT 5-9
Space Network Customer Services	10,500	--	--	SAT 5-15
Total	406,300	--	--	

Distribution of Program Amount by Installation

Johnson Space Center	172,500	--	--
Kennedy Space Center	1,100	--	--
Marshall Space Flight Center	800	--	--
Dryden Space Flight Center	12,800	--	--
Glenn Research Center	10,100	--	--
Goddard Space Flight Center	71,500	--	--
Jet Propulsion Laboratory	131,700	--	--
Headquarters	5,800	--	--
Total	406,300	--	--

Note -- In FY 2001, funding for these activities were requested under the Space Operations program under the Science, Aeronautics, and Technology Appropriation and in FY 2002, funding for all these activities is consolidated in the Human Space Flight (HSF) appropriation account under the Space Operations program. See the crosswalk for Space Operations in the Special Issues section for comparison.

PROGRAM GOALS

The Mission Communications Services goal is to provide high quality, reliable, and cost effective space operations services which enable Enterprise mission operations. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The Space Operations Management Office (SOMO), located at the Johnson Space Center, in Houston, Texas manages the telecommunication, data processing, mission operations, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. The SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participating with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for space operations services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests. The content described in this section represents the Mission Communications Services portion of the SOMO responsibilities.

The Mission Communications Services segment of NASA's Space Communications program is composed of Ground Networks, Mission Control and Data Systems, and Space Network Customer Service. These programs establish, operate, and maintain NASA ground networks, mission control, and data processing systems and facilities to provide communications service to a wide variety of flight programs. These include deep space and Earth-orbital spacecraft missions, research aircraft missions, and sub-orbital flights. Mission support services such as orbit and attitude determination, spacecraft navigation and maneuver support, mission planning and analysis and other mission services are provided. New communications techniques, standards, and technologies for the delivery of communication services to flight operations teams and scientific users are developed and applied. Agency spectrum management and data standards coordination for NASA are conducted under this program.

STRATEGY FOR ACHIEVING GOALS

The Space Operations program provides the necessary research and development to adapt emerging technologies to NASA communications and operational requirements. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the evaluation and coordination of data standards and communication frequencies to be used in the future.

Many science and exploration goals are achieved through inter-agency or international cooperation. NASA's Space Operations assets are provided through collaborative agreements with other U.S. Government agencies, commercial space enterprises, academia, and international cooperative programs. Consistent with the National Space Policy, NASA procures commercially available goods and services to the fullest extent feasible, NASA develops selected technologies which leverage commercial investments and enable the use of existing and emerging commercial telecommunications services to meet

NASA's Space Operations needs. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

The Consolidated Space Operations Contract (CSOC) was successfully implemented on January 1, 1999 under the direction of the Space Operations Management Office and Lockheed Martin Space Operations Company as the Prime Contractor. CSOC provides end-to-end space operations mission and data services to both NASA and non-NASA customers. CSOC is a $3.44B contract with a Basic Period of Performance from January 1999 through December 2003 and an option period though December 2008. CSOC is a Performance Based Cost Plus Award Fee (CPAF) contract. A total of nine contracts have been consolidated to date, and seven further contracts to be consolidated in FY 2001 and FY 2002. CSOC reflects a significant change in NASA philosophy as accountability and day to day direction for providing space operations services shifts from NASA to the CSOC contractor.

BASIS OF FY 2002 FUNDING REQUIREMENT

GROUND NETWORKS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Deep Space Network – Systems	75,200	--	--
Deep Space Network – Operations	56,400	--	--
Spaceflight Tracking and Data Network - Systems	2,000	--	--
Spaceflight Tracking and Data Network - Operations	1,400	--	--
Aeronautics, Balloons, and Sounding Rockets - Systems	5,900	--	--
Aeronautics, Balloons, and Sounding Rockets - Operations	21,100	--	--
Total	162,000	--	--

See crosswalk in Special Issues section for comparison.

PROGRAM GOALS

The Ground Networks program goal is to provide high quality, reliable, cost-effective ground-based tracking, command and data acquisition systems and services for NASA science and aeronautics programs. Launch, emergency communications, and landing support for the Space Shuttle is also provided by the Ground Networks facilities. The program provides for the implementation, maintenance, and operation of the tracking and communications facilities necessary to fulfill program goals for the NASA flight projects. The Ground Networks program also supports NASA programs in collaborative interagency, international, and commercial enterprises and independently provides support to other national, international, and commercial enterprises on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

The Ground Networks program is comprised of the following elements: the Deep Space Network (DSN), managed by the Jet Propulsion Laboratory (JPL); the Spaceflight Tracking and Data Network (STDN), managed by the Goddard Space Flight Center (GSFC); the Aeronautics, Balloon and Sounding Rocket (AB&SR) tracking and data acquisition facilities managed by GSFC/Wallops Flight Facility (WFF); and the Western Aeronautical Test Range (WATR), managed by the Dryden Flight Research Center (DFRC).

The number of missions serviced by the DSN facilities and the requirements of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems are expected to be phased out or converted for alternate uses. The DSN has been reconfigured with four new 34-meter antenna systems located at Goldstone, California; Canberra, Australia; and Madrid, Spain. These 34-meter antennas will enable the expanded coverage requirements and provide simultaneous coverage of two deep space missions that are in critical phases. Currently, a 34-meter antenna transferred from the U.S. Army located at Goldstone is supporting the Solar Observatory for Heliospheric Observations spacecraft. An 11-meter antenna system has been installed at each DSN complex to provide science support for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operation Program (VSOP) spacecraft.

The DSN has several on-going re-engineering efforts. These new processes allow the DSN to increase the tracking hours delivered while reducing costs. The processes include giving a single operator end-to-end control of the entire data acquisition process, redesigning systems that provide support data to allow automation and quicken response time, developing a process to better define DSN services which will allow customers to choose only the services necessary to support the mission, and providing systems support data which allow greater automation and quicker response time.

The DSN is the premier facility for tracking deep space probes and is occasionally supplemented by the facilities of other agencies or nations. NASA is actively working with industry to foster the enhancement of existing "commercial-off-the-shelf" (COTS) data processing systems to expand their applicability so that inexpensive and reliable communications services can be readily obtained for the new small-class missions. Future earth orbiting missions will be supported by commercially available tracking systems, enabled by such tools as the Very Large Scale Integration (VLSI) High-Rate Frame Synchronization and Data Extraction chips which have been transferred to industry.

New Ground Networks capabilities include two 11-meter antenna systems installed near Fairbanks, Alaska and at Svalbard, Norway to provide command and data acquisition support for the expanded number of Earth-observing missions which includes EOS AM-1 and Landsat-7. Also, the Low Earth Orbit Terminal (LEO-T) contract has been expanded to provide three autonomous 5-meter ground stations for space science mission support.

The Ground Networks program, in conjunction with other NASA elements, is demonstrating and implementing Global Positioning System (GPS) flight units on NASA-sponsored missions. This demonstration seeks to minimize future tracking and navigation activities. The Student Nitric Oxide Explorer (SNOE) mission demonstrates these new capabilities using commercial flight units as the primary source of this function. The Western Aeronautical Test Range (WATR) is striving for even more efficiency as it provides NASA's capability for tracking, data acquisition, and mission control for a wide variety of flight research vehicles. The WATR provides both on-orbit and landing support to the Space Shuttle and communications with the Mir Space Station.

SCHEDULE AND OUTPUTS

	FY 2000		FY 2001		FY 2002
	Plan	Actual	Plan	Current	Plan
Deep Space Network					
Number of NASA missions	45	51	--	--	--
Number of hours of service	84,000	94,000	--	--	--
Ground Network					
Number of Space Shuttle launches	6	4	--	--	--
Number of NASA/Other ELV launches	25	22	--	--	--
Number of NASA Earth-Orbiting missions	32	32	--	--	--
Number of Sounding Rocket deployments	27	27	--	--	--
Number of Balloon deployments (scientific)	26	26	--	--	--
Number of hours of service (GN Orbital Tracking)	24,000	24,000	--	--	--
Western Aeronautical Test Range					
Number of Hours of Mission Control Center Support	1,450	2,504	--	--	--

Refer to table on HSF 6-6 for comparison purposes.

ACCOMPLISHMENTS AND PLANS

The Deep Space Network (DSN) provided over 90,000 hours of tracking support to 51 missions during FY 2000. These included NASA, NASA cooperative, and reimbursable spacecraft launches. Special tracking coverage was provided in support of spacecraft emergencies and anomalies. The number of missions serviced by the DSN facilities and the requirements of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems will be phased out or converted for alternate uses. The DSN has been reconfigured with four new 34-meter antenna systems located at Goldstone, Canberra, and Madrid. These 34-meter antennae will satisfy expanded coverage requirements, and provide simultaneous coverage of deep space missions. In FY 2000, the 70-meter antenna located at Goldstone was upgraded to provide x-band capability. An 11-meter antenna system has been installed at each DSN complex to provide science support for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operation Program (VSOP) spacecraft.

JPL engineers worked with SOMO and its industry contract partners to ensure that the integrated operations architecture design will meet the needs of deep space missions while reducing life cycle costs. In particular, a new high-level control architecture was defined for the DSN. This new service-oriented Deep Space Missions System architecture was successfully applied to DS1, MGS, and Stardust.

JPL has also been working to decrease the Deep Space Network's complexity and improve equipment reliability, thereby enabling substantial DSN operations and maintenance cost savings. Efforts along these lines include Y2K certification, improved network control, network simplification, upgrades to the 26-meter antenna subnet, replacement of aging electronics systems, and decommissioning of obsolete antennas.

The Network Simplification Project (NSP) has continued on schedule. NSP consolidates or replaces all the telemetry and radiometric DSN equipment with new technology and COTS solutions that enable advanced capabilities and remote operations. The objectives include replacing failure-prone aging assemblies, reducing system interfaces, reducing manual switches, replacing old NASA-unique protocols with industry standards, and providing new deep space mission command services to eliminate labor-intensive controller functions.

Implementation began on the telecommunications roadmap that was developed in FY 1998. The roadmap laid out a plan for using new technologies to increase the DSN's deep space communications capabilities to accommodate a growing exploration fleet while maximizing the utility of the existing DSN antennas. The first major goal of this implementation will be the addition of Ka-band reception capability on all of the DSN's 34-meter beam wave-guide antennas. An implementation plan was developed in FY 1999 that successfully passed a preliminary definition and cost review, and moved on to prototyping activities for certain key technologies. One of these technologies currently under test is a single microwave feed horn and associated cryogenic low-noise amplifiers that can receive both X-band (8 GHz) and Ka-band (32 GHz) simultaneously. The other significant effort undertaken as part of the telecommunications roadmap is the completion of the DSS-26 34-meter antenna at Goldstone. The electronics for this antenna are being developed and installed to make this antenna operational in FY 2002.

Major elements of the effort to replace aging DSN electronics include accelerated deployment of the Block V Exciters and the microwave controller. The new exciters replace 20-to-30 year old suites of uplink processing equipment -- increasing reliability, decreasing maintenance, and accommodating the pursuit of higher frequency, Ka-band communications. The microwave controller provides for computer control, allowing automation and reducing operations costs.

Additional upgrades of the unique 70 meter antennas were made to avoid obsolescence issues and develop an improved transmit capability. The 70 meter X-band Uplink task will implement a higher power transmit capability to better communicate with spacecraft in the outer solar system. The 34-meter antenna-arraying task is also nearing completion. This task has already demonstrated the improved performance achievable through the use of an array of multiple antennas and became operational in early FY 2000.

The Ground Network (GN) is comprised of tracking stations in Alaska, Bermuda, Merritt Island (MILA), McMurdo, and Wallops Island. The GN also supports critical Space Shuttle launch, emergency communications, and landing activities. The GN provides for the implementation, maintenance, and operation of the tracking and communications facilities necessary to fulfill program goals for flight projects in the NASA mission set. Missions supported also include NASA inter-agency collaborative programs, commercial enterprises, and other national, international, and commercial enterprises on a reimbursable basis. The Space Shuttle launches were successfully supported through dedicated facilities of the MILA station and the Ponce de Leon inlet annex. This support, further enabled by the implementation of the re-engineered STDN system elements, continued throughout FY 2000 and into FY 2001.

The aging 9-meter hydraulic antennas at MILA are being replaced with electric drive systems, capable of functioning without an operator. Efforts in support of this initiative began in FY 2000 and will be completed in FY 2001. Infusion of technology developed in support of receiver, exciter, and ranging subsystems was introduced in a phased manner to replace aging subsystems at MILA and Ponce de Leon throughout FY 2000.

Work continued on the replacement of the Wallops Range Data Acquisition and Computational System; this system is a range safety tool and is obsolete and expensive to maintain. Work on the 11-meter antenna system enhancements required to support the Advanced Earth Orbiting Satellite (ADEOS) II mission will be completed in FY 2001.

The Ka-Band Ground Terminal Development activity began in FY 2000. This effort will seek to demonstrate the commercial viability of providing high rate ground data acquisition in the Ka-Band area. This activity will include participation by members from various NASA centers and commercial vendors.

The NASA Dryden Flight Research Center (DFRC) Western Aeronautical Test Range (WATR) provides communications, tracking, data acquisition, and mission control for a wide variety of aeronautic and aerospace vehicles. The WATR meets widely diverse research project requirements with tracking, telemetry, and communication systems and control room complexes. Due to the nature of the aeronautical research mission, it is essential to respond to new project requirements within days or weeks rather than months or years, and to do so safely, efficiently, and economically. To accomplish this, WATR facilities, systems, and processes are designed to support a wide range of requirements, be easily reconfigured (less than one hour for control rooms), to be shared between multiple projects, and to readily interface with specialized equipment brought in by our customers. This approach provides the needed agility to be responsive while reducing costs to individual customers by increasing utilization rates. Customers of the WATR facilities include other NASA Centers, the U.S. Army, U.S. Air Force, U.S. Navy, Federal Aviation Administration, and the aerospace industry.

BASIS OF FY 2002 FUNDING REQUIREMENTS

MISSION CONTROL AND DATA SYSTEMS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Mission Control - Systems	5,300	--	--
Mission Control - Operations	177,000	--	--
Data Processing - Systems	41,600	--	--
Data Processing - Operations	9,900	--	--
Total	233,800	--	--

See crosswalk in Special Issues section for comparison

PROGRAM GOALS

The Mission Control and Data Systems program goal is to provide high-quality, reliable, cost-effective mission control and data processing systems and services for spaceflight missions; data processing, and flight dynamics services for NASA flight projects. The program provides for data systems, telecommunications systems technology demonstrations, and coordination of data standards and communications frequency allocations for NASA flight systems. The Mission Control and Data Systems program provides for the launch and early orbit implementation, maintenance, and operation of the mission control and data processing facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems. The program provides and demonstrates key technologies and innovative approaches to satisfy Strategic Enterprises' mission needs and to maximize NASA's ability to acquire commercial services that meet its communications and operations needs. Through these efforts, the program also seeks to promote sustained U.S. economic and technological leadership in commercial communications.

STRATEGY FOR ACHIEVING GOALS

The Mission Control and Data Systems program, primarily managed by the GSFC, is comprised of a diverse set of facilities, systems and services necessary to support NASA flight projects. The Lockheed Martin Space Operations Company was awarded the Consolidated space Operations Contract (CSOC) and became the primary contract responsible for systems engineering, software development and maintenance, operations, and analytical services beginning in January 1999.

The mission control function consists of planning scientific observations and preparing command sequences for transmission to spacecraft to control all spacecraft activities. Mission Operations Centers (MOC's) interface with flight dynamics and communications network, and science operations facilities in preparation of command sequences, perform the real-time uplink of command sequences to the spacecraft systems, and monitor the spacecraft and instrument telemetry for health, safety, and system performance. Real-time management of information from spacecraft systems is crucial for rapid determination of the condition of the spacecraft and scientific instruments and to prepare commands in response to emergencies and other unplanned events, such as targets of opportunity.

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOCs) for the Hubble Space Telescope (HST) program; the International Solar Terrestrial Physics (ISTP) Wind, Polar, and Solar Observatory for Heliospheric Observation (SOHO); Rossi X-ray Timing Explorer (RXTE), TOMS-Earth Probe (EP), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Fast Auroral Snapshot (FAST); Transport Region and Coronal Explorer (TRACE); and Submillimeter Wave Astronomy Satellite (SWAS) missions, and the Multi-satellite Operations Control Center (MSOCC) which supports the Compton Gamma Ray Observatory (CGRO), Upper Atmosphere Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), and Earth Radiation Budget Satellite (ERBS) missions. The Advanced Composition Explorer (ACE) and Tropical Rainfall Measurement Mission (TRMM) are also operated out of GSFC MOC's. Data processing support is provided for the ISTP/Geomagnetic Tail (Geotail) and Extreme Ultraviolet Explorer (EUVE) missions.

The CGRO has phased into the TPOCC architecture of distributed workstations first used for the International Monitoring Platform (IMP-8) mission. NASA's SAMPEX, FAST, and Submillimeter Wave Astronomy Satellite (SWAS) missions will be operated from a common control facility for Small Explorer missions. The SWAS Mission Operations Center has been completed. The Wide Field Infrared Explorer (WIRE) control center has also been completed. These workstation systems will allow for increased mission control capability at reduced cost.

The first Medium-class Explorer (MIDEX) was launched in March 2000. Approximately one spacecraft per year will be launched, with potentially every other MIDEX mission operated from GSFC, dependent on successful Principal Investigator teaming arrangements. To minimize operations costs, plans for the MIDEX missions include consolidating the spacecraft operations, flight dynamics and science data processing all into a single multi-mission control center. Many of the functions will be automated using a commercial expert system product. The control center system will be used for spacecraft integration and test, thereby eliminating the need and cost of unique spacecraft manufacturers integration and test systems.

Other mission control systems include the Space Shuttle Payload Operations Control Center (POCC) Interface Facility and the Command Management System. The Space Shuttle POCC Interface Facility (SPIF) is being upgraded with a low-cost, PC-based front-end data system now operating in shadow mode. The SPIF provides a single interface to the Mission Control Center for use of spacecraft mission control facilities to access spacecraft deployed by the Space Shuttle. The Command Management System generates command sequences to be used by mission control centers. A User Planning System, currently being upgraded to a workstation-based environment compatible with the Network Control Center (NCC) configuration, is provided for scheduling communications with spacecraft supported by the Tracking and Data Relay Satellite System (TDRSS); and the Flight-to-Ground Interface Engineering Center provides flight software pre-flight and in-flight simulation and development support for GSFC flight systems. An Operations Support Center maintains status records of in-flight NASA systems.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data prior to its distribution to science operations centers and to individual instrument managers and research teams.

Data processing facilities include the Packet Data Processing (PACOR) facility, the Data Distribution Facility, and the Telemetry Processing Facility. The PACOR facility utilizes the international Consultative Committee for Space Data Systems data protocol to facilitate a standardized method of supporting multiple spacecraft. PACOR provides a cost-effective means of processing flight data from SAMPEX, EUVE, CGRO, SOHO, SWAS, RXTE, TRMM, and HST spacecraft missions. The transfer of EUVE to the University of California at Berkley in FY 1998 and the relocation of CGRO processing to the workstation-based PACOR II in FY 1998 resulted in the closure of the older PACOR I system. In FY 2000, the Earth Science Systematic data set was enhanced by launches of EOS PM, SeaWinds on ADEOS II, and the French Jason-1 Ocean Altimetry missions.

The Data Distribution Facility (DDF) performs electronic and physical media distribution of NASA space flight data to the science community. The DDF has been a pioneer in the use of Compact Disk-Read Only Memory technology for the distribution of spacecraft data to a large number of NASA customers. Specialized data processing services are provided by the Telemetry Processing Facility for the ISTP missions (Wind, Polar, and Geotail). The Spacelab Data Processing Facility located at the MSFC, processes data from Space Shuttle payloads. Specialized telemetry processing systems for NASA's Space Network is also provided under this program.

The Mission Control and Data Systems program provides for the operation, sustainment, and improvement of NASA's Flight Dynamics Facility (FDF). Funding for the FDF is used to: provide orbit and attitude determination for operating NASA space flight systems, including the Tracking and Data Relay Satellite (TDRS) and the Space Shuttle; develop high-level operations concepts for future space flight systems; modify existing FDF systems to accommodate future missions; develop mission-unique attitude software and simulator systems for specific flight systems; generate star catalogues for general use; and conduct special studies of future orbit and attitude flight and ground system applications. It is critical to continuously know the location of spacecraft so as to communicate with the system and to know the orientation of the spacecraft to assess spacecraft health and safety and to perform accurate scientific observations. The type and level of support required by spacecraft systems is dependent on the design of its on-board attitude and control systems, including its maneuver capabilities, and the level of position and pointing accuracy required of the spacecraft. Automated orbit determination systems for TDRS and other spacecraft systems are also under development.

Besides the operation of currently deployed spacecraft and the modification and development of mission control and data processing systems to accommodate new flight systems, the program also supports the study of future flight missions and ground system approaches. Mission control and first-order data processing systems are less costly systems. Yet, proper economy of mission planning requires solutions that integrate ground and flight system development considerations. Special emphasis is given by the Mission Control and Data Systems program to seeking integrated solutions to spacecraft and ground systems designs that emphasize spacecraft autonomy; higher data transmission and processing rates; ease and low cost of operation; reuse of software; and selected use of advanced hardware and software design techniques to increase the return of space flight system investments at equal or lower cost than is required to support today's mission systems.

The Mission Control and Data Systems program supports advanced technology development at GSFC, JPL and GRC. The GSFC team, including contractors and universities, provides advanced technology in several area such as tracking and data acquisition future systems, communications and telemetry transport, and advanced space systems for users. Anticipating a future mission set characterized by large numbers of rapid, low-cost missions, the JPL team invests in technologies that can increase the overall capacity-to-cost ratio for the Deep Space Network. Efforts are focused on core technologies unique to, and critical for, deep space telecommunications, tracking and navigation, and radio science. Current technology areas include antenna systems, low noise systems, frequency and timing, radio metric tracking, navigation, network automation, atmospheric propagation and optical communications. The Glenn Research Center team identifies, develops, and demonstrates advanced radio frequency antennas, amplifiers, receivers, digital communications and hybrid network technologies and services for use in NASA missions and commercial systems.

The Mission Communication Services advanced technology development has three forms that include near term (1-3 years) demonstration and application of data management and telecommunications technology and procedures, mid-range (3-5 years) development of ground and space flight communications systems; and a long-term, pre-competitive technology development and demonstration make up. Consideration of innovative applications of commercial "off-the-shelf" (COTS) technology is emphasized. Such applications often open new market opportunities to suppliers of these technologies resulting from their NASA experience. Additionally, in response to White House National Space Policy, NASA is planning to transition its communications operations to commercial services. Technology developments and demonstrations focus on technology and service gaps to enable utilization of commercially provided services.

A critical element of the Mission Control and Data Systems program is the securing of adequate frequency spectrum resources which are required in the performance of all flight missions, piloted and unpiloted, including spectrum for all active emitters as well as passive sensors. GRC, in concert with NASA Headquarters Office of Space Flight, manages these resources for the Agency and coordinates frequency spectrum requirements with other federal agencies, industry and regulatory bodies to obtain all requisite authorizations to operate telecommunications systems associated with NASA programs. Consistent with its charter pursuant to both the Space Act of 1958 and the Communications Satellite Act of 1962, NASA also serves, as an advocate for obtaining the unique frequency spectrum allocations required by the commercial sector to exploit satellite technology for future generation telecommunications systems. In compliance with the 1992 Telecommunications Authorization Act, NASA actively participates in the Interdepartment Radio Advisory Committee to establish National and International spectrum management policies.

SCHEDULE AND OUTPUTS

	FY 2000		FY 2001		FY 2002
	Plan	Actual	Plan	Current	Plan
Number of NASA spacecraft supported by GSFC mission control facilities	25	16	--	--	--
Number of mission control hours of service (thousands)	62,000	47,000	--	--	--
Number of NASA/Other missions provided flight dynamics services	49	54	--	--	--
Number of NASA/Other ELV launches supported by flight dynamics services	22	20	--	--	--

Refer to table on HSF 6-6 for comparison purposes.

ACCOMPLISHMENTS AND PLANS

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOC) for the Hubble Space Telescope (HST) program; the International Solar Terrestrial Physics (ISTP) Wind, Polar, and Solar Observatory for Heliospheric Observation (SOHO); Rossi X-ray Timing Explorer (RXTE), Total Ozone Mapping Satellite-Earth Probe (EP), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Transport Region and Coronal Explorer (TRACE); the Compton Gamma Ray Observatory (CGRO); and Submillimeter Wave Astronomy Satellite (SWAS) missions, and the Multi-satellite Operations Control Center (MSOCC) which supports Upper Atmosphere Research Satellite (UARS) and Earth Radiation Budget Satellite (ERBS) missions. The Advanced Composition Explorer (ACE), Tropical Rainfall Measurement Mission (TRMM), the International Monitoring Platform (IMP-8), and Land Satellite (Landsat-7) are also operated out of GSFC MOCs. Data processing support is provided for the ISTP/Geomagnetic Tail (Geotail) mission. Mission control of the Fast Auroral Snapshot (FAST) mission was operated under CSOC during FY 1999 and transitioned to the UCB beginning FY 2000. The pathfinder success of the earlier transition of EUVE mission operations was the basis for the FAST transition.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data (Level 0) prior to its distribution to science operations centers and to individual instrument managers and research teams.

Flight dynamics services were provided to all NASA space flight missions that utilize NASA's Space Network and to selected elements of the Ground Network, including the Space Shuttle, Expendable Launch Vehicles, and satellite systems. Attitude software and simulator development was provided for the TRACE, ACE, and TRMM flight systems.

The Mission Control and Data Processing area has pursued proactive measures to consolidate functions, close marginal facilities, and reduce overall contractor workforce to reflect the Agency's goals. Examples include the transition of both the

SAMPEX and FAST MOC operations to ITOS workstation systems and the outsourcing of FAST mission operations to the UCB, and the use of automation to monitor routine spacecraft health and safety functions to enable smaller flight operations teams and reduced operations schedules (RXTE, CGRO, Landsat-7, etc.). The completion of the ISTP Reengineering consolidation of Wind and Polar operations with SOHO was completed in FY 2000,

Transfer of data systems technologies to flight project use occurred in the areas of software reuse, expert system monitoring and command of spacecraft functions, and packet data processing systems. Software reuse, expert systems, workstation environments, and object-oriented language applications continued. The Mission Control and Data Systems upgrades areas will continue to integrate modern technology into mission operations support systems through the use of systems like the GenSAA for automation, software-based telemetry front-end processing systems and the Mission Operations Planning and Scheduling System, case-based and model-based reasoning tools, and commercial orbit planning systems.

Significant development, test, and pre-launch support associated with the MIDEX and SMEX missions are part of the Mission Control and Data Systems activity. Emphasis upon commercial products, artificial intelligence applications and advanced graphical displays continued in FY 2000 for application in MIDEX and future SMEX missions. Evolution of systems to a single integrated mission control, command management, flight dynamics, and first-level science processing system will continue. The Flight Dynamics Facility (FDF) operations concept to perform routine operations as integral functions within mission control centers continued into FY 2000. New flight dynamics technology development and infusion for autonomous space and/or ground spacecraft navigation and control will be major efforts.

During FY 2000, completed the delivery of the Vision 2000 ground system, delivery of the new flight control computer flight software, and the payload computer ACS support system in preparation for the HST Third Servicing Mission. Development efforts continued in preparation for the MIDEX MAP mission that is scheduled to launch in FY 2001.

The Mission Operations and Data Systems upgrades efforts will continue to focus efforts on operations automation beyond the RXTE Automated Mission Operations System (AMOS), the CGRO Reduced Operations by Optimizing Tasks and Technologies (ROBOTT), and the automation provided for TRACE to promote single shift staffing for operations. Mission Control and Data Systems will actively lead and participate in establishing new architecture directions and rapid prototyping, exploring system autonomy concepts, and use of commercial-off-the-shelf products.

Mission Control and Data Systems upgrades area will continue the lead in scoping and prototyping innovative architectures such as: the use of Transmission Control Protocol/Internet Protocol or Space Communications Protocol Standards for ground and flight communications; the use of knowledge-based control languages; ground and space autonomy; and active endorsement and collaboration in formulating a Space Objects technology for adoption and implementation of plug-and-play components for mission operations. Exploration of the promise of advanced communications technologies will continue throughout this period.

Development efforts on Triana, MAP, EO-1, and similar missions will realize benefits from modern technology, commercial products, and more cost-effective processes (for example, a single system to perform spacecraft integration and test and mission operations; skunkworks development teams; concurrent engineering).

BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE NETWORK CUSTOMER SERVICES

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Space Network Customer Services	10,500	--	--

See crosswalk in Special Issues section for comparison

PROGRAM GOALS

The goal of the Space Network Customer Service program is to provide high quality, reliable, cost-effective customer access to the multi-mission space telecommunications network serving all TDRS-compatible Earth orbiting and suborbital flight missions and to provide network control and scheduling services to customers of both the Space Network and selected Ground Networks elements.

STRATEGY FOR ACHIEVING GOALS

This program develops and maintains both the management and technical interfaces for customers for the Space Network. The Network Control Center (NCC), located at the Goddard Space Flight Center in Maryland, is the primary interface for all customer missions. The primary function of the NCC is to provide scheduling for customer mission services. In addition the NCC generates and transmits configuration control messages to the network's ground terminals and TDRS satellites and provides fault isolation services for the network. The Customer Services program also provides comprehensive mission planning, user communications systems analysis, mission analysis, network loading analysis, and other customer services and tests to insure network readiness and technical compatibility for in-flight communications.

The Customer Services program also undertakes network adaptations to meet specific user needs and provides assistance to test and demonstrate emerging technologies and communications techniques. A low power, portable transmit/receive terminal, called Portcom, which operates with TDRS spacecraft has been demonstrated. Potential applications include data collection from remote sites where commercial capabilities do not exist, such as NOAA ocean research buoys and National Science Foundation (NSF) Antarctic activities. A series of tests are being conducted with Japanese and European satellites and data acquisition communications systems for mutual provision of emergency operational spacecraft support.

ACCOMPLISHMENTS AND PLANS

Implementation was completed on an improved, distributed architecture for the NCC, which is Year 2000 (Y2K) compliant. This Service Planning Segment Replacement (SPSR), provides more efficient use of the network capabilities, improved ability to resolve scheduling conflicts among customer missions, and provides standard commercial protocols for both internal and customer interfaces. The NCC modifications to the scheduling system also incorporated the Request Oriented Scheduling Engine (ROSE) which provides special features for conflict-free spacecraft scheduling, such as goal-directed scheduling and repetitive activities with variable start times and duration. This architectural change was undertaken over several years and accomplished segment by segment. The Communication and Control Segment Replacement (CCSR) development effort, planned as a follow on to the SPSR, was cancelled when analysis indicated that it would not be cost effective in the current environment. Work was initiated in FY 2000 on various components of the Demand Access System (DAS), including Space Network Web-based scheduling; this effort is expected to continue through FY 2001 and become fully operational in FY 2002.

The Ka-Band Ground Terminal Development activity began in FY 2000. This effort will seek to demonstrate the commercial viability of providing high rate ground data acquisition in the Ka-Band area. This activity will include participation by members from various NASA centers and commercial vendors. The successful demonstration of this capability is scheduled for late FY 2001. Capabilities to be demonstrated are far beyond what is in operation today. Success will allow NASA and its commercial partners to take advantage of the new frequency allocations for space and earth science and to alleviate issues regarding radio frequency spectrum interference that exist today.

The requested funding also provides for continuation of mission planning, customer requirements definition and documentation, mission and network operational integration, analyses, customer communications systems analyses, test coordination and conduct, and other customer support services in support of Space Shuttle, International Space Station (ISS) and other human space flight efforts.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **SPACE OPERATIONS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Operations..		349,738		SAT 6-2
Mission and Data Service Upgrades.................................		82,811		SAT 6-3
Tracking and Data Relay Satellite System Replenishment Project		50,879		SAT 6-4
Technology		38,316		SAT 6-5
[Reimbursements [non-add]]		[[43,000]]		
Total..		521,743		
Distribution of Program Amount by Installation				
Johnson Space Center		225,593		
Kennedy Space Center		37,111		
Marshall Space Flight Center		8,800		
Dryden Space Flight Center..		12,743		
Glenn Research Center		8,990		
Goddard Space Flight Center...		92,071		
Jet Propulsion Laboratory		113,016		
Headquarters..		23,419		
Total..		521,743		

Note - See Mission Communication Services in the SAT section and Space Communications Services in the MS section for details for FY 2000 activity and the Space Operations under the HSF appropriation to discuss FY 2001 and FY 2002 activity.

BASIS OF FY 2002 FUNDING REQUIREMENT

OPERATIONS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Space Network		40,619	
Deep Space Network		149,870	
Ground Networks		36,021	
Wide Area Network		97,715	
Mission Services		8,581	
Western Aeronautical Test Range		12,472	
Spectrum Management		4,590	
Standards Management		299	
Total		349,738	

Note - See Space Operations section under the HSF appropriation to discuss FY 2001 activity.

BASIS OF FY 2002 FUNDING REQUIREMENT

MISSION AND DATA SERVICES UPGRADES

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Mission Services		32,129	
Data Services		50,682	
Total..		82,811	

Note - See Space Operations section under the HSF appropriation to discuss FY 2001 activity.

BASIS OF FY 2002 FUNDING REQUIREMENT

TRACKING AND DATA RELAY SATELLITE REPLENISHMENT PROJECT
(Thousands of Dollars)

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Spacecraft Development		14,468	
Launch Services		36,411	
Total..		50,879	

Note - See Space Operations section under the HSF appropriation to discuss FY 2001 activity.

BASIS OF FY 2002 FUNDING REQUIREMENT

TECHNOLOGY

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Advanced Communications		13,371	
Space Internet		4,989	
Virtual Space Presence		5,288	
Autonomous Mission Operations		6,585	
Advanced Guidance, Navigation, and Control		5,288	
Standards		1,297	
Technology Program Support		1,497	
Total		38,316	

Note - See Space Operations section under the HSF appropriation to discuss FY 2001 activity.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Education Programs	85,000	76,832	71,600	SAT 7.1-1
Minority University Research and Education Programs	53,800	55,875	82,100	SAT 7.2-1
Total	138,800	132,707	153,700	

SCIENCE AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS | **EDUCATION PROGRAMS**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Student support programs	10,200	7,300	20,900	SAT 7.1-6
Teacher/faculty preparation and enhancement programs	8,700	8,400	9,600	SAT 7.1-8
Support for systemic improvement of education	35,800	35,830	30,400	SAT 7.1-10
Educational technology...	28,800	23,700	9,100	SAT 7.1-14
Evaluation...	1,500	1,600	1,600	SAT 7.1-17
Total..	85,000	76,830	71,600	
Enterprise Program Funding *	[7,484]		0	
Total Program Funding	85,000	84,314	71,600	
Distribution of Program Amount by Installation				
Johnson Space Center..	4,946	998	1,000	
Kennedy Space Center..	523	599	600	
Marshall Space Flight Center..	1,319	1,996	2,000	
Stennis Space Center..	1,523	998	1,000	
Ames Research Center..	3,478	2,694	2,700	
Langley Research Center..	1,121	1,197	1,200	
Glenn Research Center...	2,772	998	1,000	
Dryden Flight Research Center..	326	499	500	
Goddard Space Flight Center..	56,539	54,380	49,100	
Jet Propulsion Laboratory..	492	499	500	
Headquarters..	11,961	11,974	12,000	
Total..	85,000	76,830	71,600	

*Note: $7,500 of the increase requested in FY 2002 represents encumbered funding previously included in the Enterprise budgets

PROGRAM GOALS

NASA's direction for education is set forth in the NASA Strategic Plan through the Communicate Knowledge crosscutting process objective to support the Nation's education goals:

> ***Educational Excellence.*** *We involve the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds.*

This objective is accomplished through implementation of a full range of NASA education programs and activities that contribute to the various efforts and activities of those involved with and in the education community, and benefit the participants as well as advance the mission of the Agency. Progress towards this goal is measured in two ways:

- **Excellence**: NASA seeks to be judged by its customer, the education community, as providing excellent and valuable educational programs and services. Therefore we will attempt to maintain an "Excellence" rating ranging between 4.3 and 5.0 (on a 5.0 scale) as rated by our customers.
- **Involvement**: NASA strives to involve the educational community in our endeavors. Therefore, at the proposed funding level, we seek to maintain a current level of participant involvement of approximately 3 million with the education community, including teachers, faculty, and students.

STRATEGY FOR ACHIEVING GOALS

In carrying out its Education Program, NASA is particularly cognizant of the powerful attraction the NASA mission holds for students and educators. The unique character of NASA's exploration, scientific, and technical activities has the ability to captivate the imagination and excitement of students, teachers, and faculty, and channel this into education endeavors which support local, state, and national educational priorities. In fulfilling its role to support excellence in education as set forth in the NASA Strategic Plan, the NASA Education Program brings students and educators into its missions and its research as participants and partners. NASA provides the opportunity for a diverse group of educators and students to experience first hand involvement with NASA's scientists and engineers, facilities, and research and development activities. The participants benefit from the opportunity to become involved in research and development endeavors, gain an understanding of the breadth of NASA's activities, and return to the classroom with enhanced knowledge and skills to share with the education community.

NASA Implementation Plan for Education

The NASA Implementation Plan for Education provides general guidance for the implementation and continual improvement of the NASA Education Program for fiscal years 1999-2003. Specifically, the plan

- Identifies three leadership strategies to improve and guide the NASA Education Program: (1) contribute to educational excellence; (2) develop alliances; and (3) involve the education community.
- Outlines the education agenda for this period through seven improvement initiatives: (1) focus and coordinate state-based efforts; (2) enhance instructional products and dissemination; (3) improve education program integration and coordination; (4) facilitate NASA research in the higher education community; (5) support preservice education; (6) target informal education; and (7) implement NASA's comprehensive data collection and evaluation system.
- Delineates the operating principles integral to the conduct of all NASA education activities: customer focus; collaboration; diversity; and evaluation.
- Defines the NASA Education Program and Evaluation Framework, the basis from which our agency-wide and center-based programs are organized, implemented, and evaluated.
- Describes the roles and responsibilities of the various organizational entities that carry out the NASA Education Program.

This plan provides guidance for agency-wide education programs as well as programs and activities carried out by the NASA Enterprise Offices, the Office of Equal Opportunity Programs, and the NASA field centers.

Program Evaluation

The NASA Education Program and Evaluation Framework was established to serve as a model to guide the implementation and evaluation of NASA's Education Program. During FY 2000, NASA has further refined and implemented the framework and the evaluation system that was first pilot tested in FY 1996. Three levels of performance measures have been developed. At the top level, all programs have measures that relate to the Program's primary metrics: excellence and involvement. Data showing progress towards these metrics are provided below. At the second level, each implementation approach has specific measures that all programs in a particular category are measured against such as career goals, program value and overall quality, curriculum integration/use, standards awareness and utilization, partnerships/alliances, service quality, and usage. At the third level, each program, in addition to the applicable second level measures, has program specific measures that show progress as well as participant written feedback that provides qualitative evaluation data.

ACCOMPLISHMENTS AND PROPOSED RESULTS

FY 2000 Achievements

In FY 2000, the NASA evaluation system was able to collect data on the agency-wide education programs, and many center- or Enterprise-specific programs and activities. The data below summarize the top-level measures that relate to the Education Program's two metrics - - excellence and involvement.

- **Excellence**: NASA seeks to be judged by its customer, the education community, as providing excellent and valuable educational programs and services. Therefore we will attempt to maintain an "Excellence" rating ranging between 4.3 and 5.0 (on a 5.0 scale) as rated by our customers.

Progress towards this metric is measured by a quality rating by the educational customer of NASA's performance. The following data were collected:

Participant ratings of excellence (score: 5=excellent to 1=very poor; total participants reporting: 13,473 participants responding; not all participants are asked all 4 questions; 112 programs reporting)

- 4.70 Recommend to others
- 4.71 Rate staff
- 4.57 Expect to apply what was learned
- 4.67 Valuable experience
- Overall average for excellence: 4.66

Based on this information, the NASA Education Program continues to meet its metric of excellence, as defined by the level of satisfaction expressed by our customers.

- **Involvement**: NASA strives to involve the educational community in our endeavors. Therefore, at the proposed funding level, we seek to maintain a current level of participant involvement of approximately 3 million with the education community, including teachers, faculty, and students.

Progress towards this metric is measured in two ways: (1) total number of participants, including students/teachers/faculty/administrators involved in NASA education programs; and (2) number of partnerships/collaborations. The following data were collected:

Participants

- Total in-person involvement in NASA Education activities: 3,248,191
- Total involvement in NASA Education activities: 37,478,958 (164 programs reporting)
- Participants identified by type:
  - Students: 53%
  - Teachers/faculty: 20%
  - Administrators, civic, parents, etc.: 27%
- Types of K-12 schools represented (4,579 participants reporting)
  - 32% urban; 31% suburban; 37% rural

Partnerships

  - 9,030 instances of alliances
  - higher education institutions; industry; contractors; other NASA facilities; Educator Resource Center Network; non-profits; local community; school districts

It is clear from the numbers provided above that the NASA Education Program continues to exceed the metric of involving 3 million direct participants in our programs, and we anticipate continuing to do so in FY 2001.

FY 2002 Plans

In FY 2002, NASA's Education Program funding request of $71.6M provides for continued maintenance of a broad, comprehensive education program. This request provides core funding for agency-wide student support, teacher/faculty preparation/ enhancement, support for systemic improvement, educational technology, and evaluation programs, as outlined in the following sections. Under this funding scenario, two major challenges confront the Education Program: 1) how to strengthen the competitiveness and the stability of the core university program; and 2) how to responsibly manage Congressionally directed programs in ways that both meet the intent of Congress and fit within the framework of NASA's Education Program.

BASIS OF FY 2002 FUNDING REQUIREMENT

STUDENT SUPPORT PROGRAMS

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Elementary and secondary	3,800	3,800	4,300
Higher education	6,400	3,500	16,600
Total	10,200	7,300	20,900

PROGRAM GOALS

The goal of the Student Support Program is to use the NASA mission, facilities, human resources, and programs to provide information, experiences, and research opportunities for students at all levels to support the enhancement of knowledge and skills in the areas of science, mathematics, engineering, and technology.

STRATEGY FOR ACHIEVING GOALS

Student support activities: (1) provide NASA mission experiences and information that are designed to promote students' interest and achievement in science, mathematics, technology, and geography; (2) provide exposure to NASA research and/or research experiences and activities to promote science, mathematics, technology, engineering, and geography career awareness; (3) provide support to the science and technology workforce pipeline by including greater participation of individuals who are under represented in science, mathematics, technology, and geography in NASA student programs; and (4) increase the number of NASA student support opportunities through partnerships and interagency cooperation and collaboration. Examples of how these objectives are put into practice are provided below.

Activities such as the NASA Student Involvement Program (NSIP) and the Shuttle Amateur Radio Experiment (SAREX) provide general exposure to NASA's mission and stimulate interest in mathematics, science, and technology subject matter by providing opportunities for students to develop experiments to be tested in or on a NASA research facility or to communicate directly with astronauts via amateur radio. Additional activities such as the Summer High School Apprenticeship Research Program (SHARP), demonstrate the applications of mathematics, science and technology by providing research experiences for students who traditionally have not been represented in mathematics, science and engineering fields. These experiences take place at NASA field centers or at university laboratories. At the higher education level, activities such as the Graduate Student Researchers Program (GSRP) provide support to train students in NASA-related disciplines at both the master's and doctoral levels, again providing actual field center experience when applicable.

ACCOMPLISHMENTS AND PROPOSED RESULTS

In FY 2000, 1,098,826 students participated in NASA education activities. Elementary/secondary students comprised almost 96% of that number, in a variety of programs, projects, and activities.

In FY 2000, NASA developed the Undergraduate Student Research Program, a coordinated, agency-wide, research opportunity for undergraduate students. This program was designed to increase diversity in the pipeline for NASA, and to fill a gap in programs at the undergraduate level, providing a bridge from our high school programs to our graduate programs. The pilot program was announced in early 2001 and is scheduled to commence with a group of 80-100 students in May 2001.

FY 2001and FY 2002 also bring, with the staffing of the International Space Station, the opportunity to integrate ISS into many of our existing student support activities, especially at the K-12 level.

In FY 2002, funding for Student Programs has been increased due to the planned development and implementation of a NASA Scholarship Program in Science and Engineering. These competitive scholarships will be awarded only for study in disciplines critical to NASA's future needs. NASA will be seeking authority to establish a service requirement as a condition for receiving these scholarships, to ensure that their investment will provide an important source for bringing the best and brightest into NASA. There will be a significant mentoring component to ensure student retention as well as opportunities for students to participate in internships at NASA Centers. Planning is currently underway for students beginning the fall 2002 academic year. Additional funding has also been provided for a nominal increase in stipends for graduate fellowships and an increase in participant opportunities for undergraduate research. In addition, the FY 2002 request represents encumbered funding for graduate fellowships previously included in the Enterprise budgets.

An area of challenge that continues to confront the higher education programs, is graduate fellowship opportunities. Therefore stipends must be raised even higher in order to remain competitive with similar Federal fellowship programs.

BASIS OF FY 2002 FUNDING REQUIREMENT

TEACHER/FACULTY PREPARATION AND ENHANCEMENT PROGRAMS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Elementary and secondary	3,700	3,700	4,200
Higher education	5,000	4,700	5,400
Total	8,700	8,400	9,600

PROGRAM GOALS

The goal of the Teacher/Faculty Preparation and Enhancement Programs is to use the NASA mission, facilities, human resources, and programs to provide exposure and experiences to educators and faculty, to support the enhancement of knowledge and skills, and to provide access to NASA information in science, mathematics, technology, engineering, and geography.

STRATEGY FOR ACHIEVING GOALS

At the elementary and secondary level, preparation and enhancement activities are designed to (1) provide NASA mission-based programs that introduce the application of science, mathematics, geography, engineering, and technology for use in student learning activities; (2) provide educators with a wider range of alternatives using scientific inquiry, based on the NASA mission; (3) encourage a "multiplier" effect to expand the benefits of the in service program beyond participants to include additional educators; (4) provide access to and promote utilization of NASA related materials and information resources; (5) increase the participation of under served and under utilized individuals and groups; and (6) facilitate collaborations between the faculty of teacher preparation departments and the faculty of scientific and technical departments to develop innovative approaches to teacher preparation. Examples of how these objectives are put into practice are provided below.

Pre-service programs such as Project NOVA, and in-service programs such as the NASA Education Workshops (NEW) and the Urban Community Enrichment Program (UCEP) are designed to enhance and improve the teaching of mathematics, science, and technology by demonstrating their applications in aeronautics and space through workshops around the country, in school districts and at NASA field centers. The Teaching from Space Program continues to provide instructional products that help support these preparation and enhancement workshops, drawing from in-flight experiences of Space Shuttle and International Space Station crews.

At the higher education level, activities are designed to enhance faculty research skills and content knowledge; balance participation so that a cross-section of colleges and universities is represented (i.e., community colleges, four year institutions, institutions that serve significant numbers of under represented groups, under funded institutions); and provide opportunities for curriculum expansion/revision that aligns with the mission needs of NASA and universities. Activities such as the Summer Faculty Fellowship

Program (SFFP) provide research experiences for faculty at NASA field centers to further their professional knowledge in the engineering and science disciplines, and to ultimately enhance the undergraduate/graduate curriculum.

ACCOMPLISHMENTS AND PROPOSED RESULTS

In FY 2000, 395,136 educators and faculty participated in NASA education activities. K-12 educators comprised approximately 67% of that number.

General plans for teacher/faculty preparation/enhancement programs in FY 2001 and FY 2002 include plans to expand the scope of educator enhancement programs to include workshops at each center for institutions in their region that serve informal education and urban/rural systemic efforts; provide education experiences for educators in the effective application of educational technologies; and define and execute activities that target preservice education programs. FY 2001/2002 also bring, with the staffing of the International Space Station, the opportunity to integrate ISS into many of our existing teacher workshop activities.

In FY 2002, we will begin the redesign of our center-based NASA Education Workshop (NEW) program, in an effort to better meet the needs of today's educators, and to broaden the reach of the program.

FY 2002 will also mark the first year of the redesigned Summer Faculty Program. This program is currently undergoing changes that will provide for greater follow-on research opportunities for participating faculty and better linkages with the undergraduate curriculum.

In FY 2002, funding for Teacher/Faculty Preparation/Enhancement Programs will be maintained at the same approximate level as in FY 2000 and 2001. Changes in funding reflect some internal programmatic requirements and priorities. Presuming stable funding, participation levels for K-12 activities should also remain at similar levels. A slight increase has been added at the higher education level in order to provide a nominal increase in stipends for faculty fellowships.

However, challenges continue to confront the higher education program, such as summer faculty opportunities since stipends must be raised even higher in order to remain competitive with similar Federal faculty programs.

BASIS OF FY 2002 FUNDING REQUIREMENT

SUPPORT FOR SYSTEMIC IMPROVEMENT OF EDUCATION

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Aerospace Education Services Program (AESP).................................	6,200	6,230	6,200
National Space Grant College and Fellowship Program.....................	19,100	19,100	19,100
Experimental Program to Stimulate Competitive Research...............	10,000	10,000	4,600
Innovative Reform Initiatives...	500	500	500
Total	35,800	35,830	30,400

PROGRAM GOALS

The goal of the Support for Systemic Improvement of Education Program is to use NASA's unique assets to support local, state, regional, and national science, mathematics, technology, engineering, and geography education improvements through collaboration with internal and external stakeholders.

Systemic improvement encompasses the process whereby an entire system is re-engineered toward achieving a new goal. NASA is committed to supporting systemic initiatives in the areas of science and mathematics education, and its activities vary depending on the needs of the institution, school system, and/or state. Thus, the activities supported by programs included in this category seek to provide a range of support in response to the needs of the customer community.

STRATEGY FOR ACHIEVING GOALS

Systemic improvement activities are designed to: (1) coordinate planning among NASA education initiatives to ensure alignment with and support of standards-led systemic improvement initiatives of the states; (2) redirect existing education programs, and ensure new initiatives address state needs and tie together unique education and economic development efforts; (3) support standards-based science, mathematics, technology, and geography education change by aligning NASA educational programs and products with the national/state standards; and (4) expand interactions with external stakeholders involved in the systemic improvement of education at all levels.

A major program at the elementary and secondary education level is the Aerospace Education Services Program (AESP). The AESP's primary focus is teacher enhancement with emphasis on and support for local, state, regional and national mathematics, science, and technology education efforts through collaboration of internal and external stakeholders in high impact reform activities.

Systemic Improvement activities at the higher education level use partnerships, linkages, and collaborations to provide activities and experiences designed to enhance research and educational capabilities, and enhance the collaborative capabilities of a diverse set of academic institutions. Programs such as Space Grant and Experimental Program to Stimulate Competitive Research (EPSCoR) play a major role in NASA's contribution towards these efforts.

The Space Grant Program, authorized by Congress in 1987, increases the understanding, assessment, development, and use of aeronautics and space resources. All 50 states, Puerto Rico, and the District of Columbia have Space Grant Consortium programs in which more than 700 affiliates participate. These consortia form a network of colleges and universities, industry, state/local governments, and nonprofit organizations with interests in aerospace research, training, and education.

The NASA EPSCoR Program provides seed funding that will enable eligible states to develop an academic research enterprise directed toward long-term, self-sustaining, nationally competitive capabilities in space and Earth science and applications, aeronautical research and technology, and space research and technology programs. This capability will, in turn, contribute to the state's economic viability. In August 2000, NASA EPSCoR was redesigned with the highest priority being to better align the research funded by EPSCoR with the Enterprises.

Systemic improvement at both the pre-college and higher education levels is captured in NASA's Innovative Reform Initiatives program which is supportive of standards-based systemic improvement efforts, and focuses on science, mathematics and technology education. A means of supporting systemic improvement is through partnerships with professional education associations, national aerospace education associations, industries, other Federal agencies, and state and local groups. When NASA becomes a partner with these groups, its role may be one of leadership, being a participant, or acting as a facilitator to empower and enable wide reaching educational reform that is systemic in nature. An example of these partnerships is NASA's work with the National Alliance of State Science and Math Coalitions (NASSMC).

ACCOMPLISHMENTS AND PROPOSED RESULTS

Performance in this area is measured in a variety of ways, including partnerships/alliances, supplemental funding, and standards. In FY 2000, NASA documented 9,030 alliances with a variety of partners (note, a program may be involved in multiple alliances):

4% NASA Contractors; 6%Other Industry; 1% Local Community; 2 % Museums/Planetariums; 4% Non Profit; 3% Federal Agencies; 42% higher Education Institutions; 7% Other NASA; 13% K-12 Schools; 3% K-12 School Districts; 6% NASA HQ Program Office; 2% State Government; 5% Education Resource Centers. Partners included schools (K-12 and higher education), industry, and non-profit organizations.

More than $88M was secured in supplemental funding, of which 15% came from other Federal agencies, 6% from state agencies, 45% from Educational Organizations and Institutions; 1% from industry/business, and local organizations.

The data below provide examples of accomplishments of the two largest systemic programs—Space Grant and EPSCor:

Space Grant (FY 1999 data)

- 52 University-based Consortia
- Space Grant involves 761 affiliates which include:
  - 500 colleges and universities
  - 63 business/industry
  - 34 State and local government agencies
  - 164 other affiliates (science museums, not for profits, etc.)
- $53.6M in matching funds (32% university; 24% other Federal, 13% industry; 21% other; 10% local/state government)
- 2,182 fellowships and scholarships (75% undergraduate; 22% under represented groups; 43% women)
- 573 research programs; $6.5M funded proposals; 384 publications
- 1,048 education programs; $14.2M funded proposals
- 399 public service programs; 4.9M people served

EPSCoR

- Awards to twenty states
- Alabama, Arkansas, Kentucky, Louisiana, Montana, Puerto Rico, Kansas, Nebraska, Oklahoma, South Carolina – original grants and prep grants
- Idaho, Kentucky, Louisiana, Maine, Mississippi, Nebraska, Nevada, South Dakota, Vermont, West Virginia – prep grants
- Participants: **(FY 1998 data)**
  - Institutions: 88
  - Research clusters: 42
  - Faculty: 252
  - Post doctoral fellowships: 56
  - Graduate students: 317
  - Undergraduates: 242
- $68.2M proposals funded
- 276 publications, refereed papers
- 1 patents; 12 patent applications; 3 invention disclosure

General plans for Systemic Improvement activities in FY 2001 and FY 2002 include providing professional development on standards-based education initiatives to NASA's internal education community; reviewing existing NASA education initiatives to ensure their alignment with the vision and philosophy for state-based systemic reform; designing new programs or redesigning existing programs to ensure that all NASA efforts align with the science, mathematics, technology, and geography education standards and supporting the needs of those engaged in the implementation of standards-based education at the state and local levels; leveraging the use of NASA programs and resources by expanding NASA interactions and cooperation with all stakeholders involved in national and state systemic initiatives; and implementing a plan through the field centers that supports the needs of individual states.

Congressional direction in FY 2001 for the NASA EPSCoR Program increased the funding for this program to $10.0M. This has enabled NASA to conduct a selection process for a revamped EPSCoR program that better aligns with the research mission of the NASA Enterprises. Awards are expected to be announced in Spring 2001. One of our challenges with this program is how, under the current funding structure, to both broaden and strengthen the reach of the NASA EPSCoR Program. While the FY 2002 request reduces program funding to 4.6M, we anticipate reducing rather than eliminating funding for those states selected in this process.

In FY 2002, funding and therefore, participation levels, for other Systemic Improvement activities will be maintained at approximately the same level as in FY 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

EDUCATIONAL TECHNOLOGY

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Learning tools...	3,800	3,242	3,300
Demonstrations..	2,000	1,996	2,000
Learning Technologies Project..	4,000	0	3,800
Franklin Institute	1,400	--	
Jason XI.......................	2,100	2,495	
Sagan Discovery............... ..	900	998	
Texas Learning..................... ..	3,700	--	
Space Science Museum....................	3,600	--	
Ohio View......... ..	1,800	--	
Completion of Science Learning Center in Kenai, AK	900	998	
Lewis & Clark – Re-discover Web Tech	1,800	1,996	
Univ. of San Diego for Sci & Ed Tech	500	998	
City of Ontario CA for Sci & Ed Tech	500		
Univ. of Redlands, Academic Infrastructure	1,800	2,993	
Science Facilities Initiative, Heidelberg College, OH	--	998	
Univ. of Wisconsin-Milwaukee, Initiative for Math, Science, Tech.	--	1,996	
NASA Glenn “Gateway to the Future: Ohio Pilot”	--	998	
Santa Ana College Space Education Center, CA	--	1,497	
Univ. of North Carolina, Chapel Hill – Science Education Facility	--	499	
Science Learning Center, Hammond, IN	--	998	
Environmental Science Learning Center, Los Angeles, CA	--	998	
Total	28,800	23,700	9,100

* - FY 00 and FY 01 totals reflect Congressional interest projects added as part of the Congressional appropriation process.

PROGRAM GOALS

The goal of the Educational Technology program is to research and develop products and services that facilitate the application of technology to enhance the educational process for formal and informal education and lifelong learning.

STRATEGY FOR ACHIEVING GOALS

The Educational Technology program (1) produces technology-based teaching tools and strategies that are grounded in or derived from the NASA mission; (2) uses emerging technologies for, and applies existing technologies to, educational programs; (3) utilizes technology to facilitate communication within the educational community; (4) involves educators in NASA missions through innovative uses of technologies; and (5) conducts research into new teaching and learning practices that are made possible through NASA mission-derived technology.

The NASA Classroom of the Future (COTF) continues to be a major component of the educational technology program, demonstrating how NASA technologies and research results can be translated into learning tools, demonstrations, and teacher enhancement programs that support standards-based education reform.

Specific learning tools such as NASA CONNECT, an instructional television and web-based series, demonstrating work place math, science, and technology as collaborative processes, and NASA Spacelink, an electronic resource specifically developed for the educational community, provide additional resources for educators to use in and out of the classroom.

The Learning Technologies Project provides demonstration projects and on-line systems dedicated to bringing NASA science to teachers and students in the classroom using examples from NASA's unique missions. The goal of this program is to accelerate the implementation of a national information infrastructure through NASA science, engineering, and technology contributions and to facilitate the use of technologies within the K-12 education systems.

ACCOMPLISHMENTS AND PROPOSED RESULTS

Performance in this area is measured in a variety of ways, including overall quality, type/number of users; standards application; internet hits; data transferred; searchable pages; and unique IP addresses.

General plans for this program area include providing technology training and support for the persons involved in the operation of the Educator Resource Center Network and the Space Grant program; implementation of a coordinated electronic dissemination system that ensures that all NASA education activities and products are available through appropriate networking technologies; demonstrate NASA's educational technology resources at professional development conferences; develop innovative learning tools and technologies that are integrated with curriculum support and teacher enhancement activities ; develop, implement, and evaluate distance education and virtual mentoring projects; and support distribution of excess NASA equipment to schools and institutions of higher education.

Examples of accomplishments include:

- WWW Requests (Hits): 815M; Data Transfer Volume (GB): 11.7B; Unique IP Addresses: 1.4B
- CD ROMS provided for Curriculum Support: 20,359; NASA materials distributed: 1M; NASA materials demonstrated: 31.7K
- 51% of Teachers responding integrate NASA materials into their curriculum
- 154,000 Visits to NASA Educational Resource Centers

- Programs supporting standards: 66% Science; 49% Math; 39% Technology; 25% Geography; 41% State Frameworks; 20% Local Frameworks
- Distance Education: 112K “Open Mike Interactive” Students/Teachers”; 34.5M Anonymous Students/Teachers; 106M TV/Radio Audiences
- Programs using NASA facilities: 51% Laboratories; 39% Teleconferencing; 25% Aircraft; 50% Computer Labs; 25% Hangers; 21% Mockup Facilities; 25% Spacecraft Displays’ 19% Wind Tunnels; 21% Clean Rooms.
- 39% of Programs brief educators on acquiring excess computers for their schools.

FY 2002 requested funding for Educational Technology demonstrations, tools, and the Learning Technology Program is similar to the FY 2001 level and no major program changes are expected. (Note: in FY 2001, funding for the Learning Technologies Program was provided by the Enterprises. This funding has now been incorporated into the Education Program budget for FY 2002. The effect of this transfer in funding was “seamless” to the program as oversight continues to be provided by the Education Division, Office of Human Resources and education.

Educational Technology activities in FY 2000 include funding for the following activities directed by Congress in the Conference Report accompanying the VA-HUD-Independent Agencies Appropriation Act: the Franklin Institute, Jason XI, Sagan Discovery, Texas Learning, Space Science Museum, Ohio View, Completion of Science Learning Center in Kenai, AK, Lewis & Clark, University of San Diego for Science & Education Center, City of Ontario California for Science & Education Center, University of Maryland Advanced Information Technology Center, University of Redlands Academic Infrastructure, and Residential Aerospace Education Center at the Glenn Research Center.

Educational Technology activities in FY 2001 include funding for the following: continuing funding for Jason XI, Sagan Discovery Center, Science Learning Center in Kenai, AK, Lewis & Clark web tech program, University of San Diego for a science/educational technology program, and the University of Redlands. New programs include: Science Facilities Initiative at Heidelberg College (OH), Initiative for Math, Science, Technology at the University of Wisconsin-Milwaukee, NASA Glenn Gateway to the Future project, Space Education Center at Santa Ana College (CA), Science Education Facility at the University of North Carolina in Chapel Hill (NC), Science Learning Center in Hammond (IN), and an Environmental Science Learning Center in Los Angeles (CA).

BASIS OF FY 2002 FUNDING REQUIREMENT

EVALUATION

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Evaluation	1,500	1,600	1,600

PROGRAM GOALS

The goal of the evaluation program is: to provide a substantive accounting and evaluation of the performance of NASA's educational program, with its associated projects and activities, in the implementation of its goals by developing and maintaining a systematic strategy for collecting, aggregating, and reporting evaluation indicator data.

STRATEGY FOR ACHIEVING GOALS

NASA has undertaken a comprehensive effort to evaluate its education programs in order to demonstrate the accomplishment of achievable and measurable goals and objectives. A set of standard, agency-wide indicators, metrics, and evaluation instruments has been developed for agency-wide use. The data are collected on-line in a single database capable of providing correlation and report generation capability. External, third-party education evaluation experts provide additional guidelines and criteria for the analysis of qualitative and quantitative data facilitating in-depth evaluations of various programs.

ACCOMPLISHMENTS AND PROPOSED RESULTS

NASA continues to refine a comprehensive system to evaluate its Education Program in order to demonstrate the accomplishment of achievable and measurable goals and objectives. Based on recommendations provided by a study of the NASA Education Program by the National Research Council (NRC), NASA established program goals and defined a comprehensive Education Framework that captures the elements of NASA's Education Program. This framework is detailed in NASA's *Implementation Plan for Education*, and supported by implementation plans developed by the Enterprises and NASA field installations between FY 1995 and the present. NASA utilizes an Internet-based system, for the collection, analysis, evaluation and reporting of standard and program unique data and program outcomes for all NASA education programs.

NASA's Education Data Collection and Evaluation System (EDCATS), continues to add programs incrementally until all NASA education programs are included. As programs compile a firm set of baseline data, selected annual program targets will be established or reviewed, as needed or required. By FY 2002 the system will be fully operational, tracking data and evaluation metrics for the entire NASA Education Program.

SCIENCE, AERONAUTICS AND TECHNOLOGY

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

ACADEMIC PROGRAMS **MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousand of Dollars)			
Historically Black Colleges and Universities	35,900	36,377	48,900	SAT 7.2-12
Institutional Science, Engineering and Technology Awards	--	3,483	11,544	
Principal Investigator Awards	6,429	4,445	7,650	
Math and Science Education Awards	20,894	14,429	18,180	
Partnership Awards	8,577	14,020	11,526	
Enterprise Program Funding *	[17,200]	[20,900]	[--]	
Other Minority Universities	17,900	19,500	33,200	SAT 7.2-17
Institutional Science, Engineering and Technology Awards	--	3,063	11,563	
Principal Investigator Awards	3,500	1,119	2,269	
Math and Science Education Awards	11,300	11,300	15,303	
Partnership Awards	3,100	4,018	4,065	
Enterprise Program Funding *	[11,600]	[15,300]	[--]	
Total Minority University Research Programs	53,800	55,877	82,100	
Total Enterprise Program Funding *	[28,800]	[36,200]	[--]	
Total Program Funding to Minority University Research	82,600	92,077	82,100	

FY 2000 and FY 2001 budgets reflect a higher level than FY 2002 due to the adding of Congressional interest as part of the FY 00 and FY 01 Congressional appropriation process.

* $36,200-increase in FY 2002 represents encumbered funding previously included in the Enterprise budgets.

ACADEMIC PROGRAMS **MINORITY UNIVERSITY RESEARCH AND EDUCATION PROGRAM**

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET
	(Thousands of Dollars)		
Distribution of Program Amount by Installation			
Ames Research Center (ARC)	1,715	1,669	1,750
Dryden Flight Research Center (DFRC)	1,256	870	1,250
Glenn Research Center (GRC)	6,875	5,324	3,942
Goddard Space Flight Center (GSFC)	26,132	33,164	60,777
Jet Propulsion Laboratory (JPL)	1,540	300	300
Johnson Space Center (JSC)	1,972	2,072	1,198
Kennedy Space Center (KSC)	3,262	2,467	1,993
Langley Research Center (LaRC)	1,100	2,307	3,133
Marshall Space Flight Center (MSFC)	6,300	4,825	5,130
Stennis Space Center (SSC)	1,442	783	500
Headquarters (HQ)	2,206	2,096	2,127
Total	53,800	55,877	82,100

PROGRAM GOALS

The Minority University Research and Education Programs (MUREP) focus primarily on expanding and advancing NASA's scientific and technological base through collaborative efforts with Historically Black Colleges and Universities (HBCU) and Other Minority Universities (OMU), including Hispanic-Serving Institutions (HSI) and Tribal Colleges and Universities (TCU), hereafter referred to as Minority Institutions (MI). NASA's outreach to MI's in FY 2002 will build upon the prior years' investments in MI research and academic infrastructure by expanding the Agency's research base; contributing to the science, engineering and technology pipeline; and promoting educational excellence in all MUREP. Through sufficient infrastructure-building support, exposure to NASA's unique mission and facilities, and involvement in competitive peer review and merit selection processes annually, MI's will be able to contribute significantly to the Agency's strategic goals and objectives. These contributions include the education of a more diverse resource pool of scientific and technical personnel who will be well prepared to confront the technological challenges to benefit NASA and the Nation. In addition to the Federal mandates for MI's, the strategic goals that guide NASA's MUREP are: (1) To foster research and development activities at MI's which contribute substantially to NASA's mission; (2) To create systemic and sustainable change at MI's through partnerships and programs that enhance research and educational outcomes in NASA-related fields; (3) To prepare faculty and students at MI's to successfully participate in the conventional, competitive research and education process; and (4) To increase the number of students served by MI's to enter college and successfully pursue and complete degrees in NASA-related fields.

STRATEGY FOR ACHIEVING GOALS

NASA employs a comprehensive and complementary array of strategies to achieve these goals for MI's. These strategies include: (1) Working closely with NASA Strategic Enterprises, other government agencies, and interested parties to develop new research and education collaborations and partnerships; (2) Encouraging and providing opportunities for faculty to conduct NASA research early in their careers; (3) Providing incentives for students to enter and remain in mathematics, science and technology disciplines; (4) Establishing measurable program goals and objectives; and (5) Developing and implementing evaluations to assess the effectiveness and outcomes of the programs and financial performance, and thereby improving program delivery and results. A strategy used to expand MI involvement in competitive peer review processes and to ensure the relevance of research conducted by MI's is to involve NASA Strategic Enterprises early in the development of solicitation notices. Once Headquarters issues the notices, NASA Centers provide advice to prospective grantees, conduct peer reviews of proposals, and provide funding recommendations to the Office of Equal Opportunity Programs (OEOP) and the Strategic Enterprises. After Headquarters makes the selections, the research is returned to the nominating NASA Center(s) or Jet Propulsion Laboratory (JPL) for grant award and/or technical management of the award. OEOP provides policy direction and program oversight. Oversight of the research performed at MI's is conducted by the Strategic Enterprises in collaboration with OEOP. In addition, all MUREP requests for continuation funding are annually assessed for performance by the NASA Technical Officers and all awards funded for more than 2 years receive on-site reviews.

The successful deployment of these strategies has resulted in the establishment of four different programmatic award categories which apply equally to the HBCU and OMU Programs. These programmatic initiatives are carried out in close collaboration with NASA Strategic Enterprises and Centers/JPL. Strategic Enterprises and Centers/JPL support the MUREP through use of their facilities, and commitment of their personnel to serve on Technical Review Committees (TRC) and assist in other facets of program implementation. Institutional Science, Engineering and Technology (ISET) Awards combine the University Research Centers (URC) and Institutional Research Awards (IRA) under one award category. The ISET awards receive technical guidance and annual on-site reviews by TRC's. The awards for Principal Investigators (PI), Mathematics, Science, and Engineering (MSE), and Partnerships are managed predominately by personnel at the NASA Centers/JPL. As a result of the involvement of the Strategic Enterprises and NASA Centers/JPL in the MUREP, numerous students and PI's from MI's are knowledgeable about and make significant contributions to the Nation's space program.

In FY 2002, the existing awards in all four programmatic award categories will be maintained. However, the University Research Center (URC) and Institutional Research Awards (Research) has been consolidated into one award titled Institutional Science, Engineering and Technology (ISET) Awards. This adjustment was made to better reflect the emphasis on strengthening the institution's research capability and achieving outcomes that enhance the institution. The Institutional Research Awards for the Networks and Research Training Sites (NRTS) has been moved to Partnership Awards to better reflect this group of awards' contributions to NASA's educational technology goals. Outreach to MI's will continue to be made in collaboration with the Strategic

Enterprises and Centers/JPL to ensure that MI's are knowledgeable of and responsive to the Agency's Strategic Plan. OEOP will continue to set specific program goals that lead to measurable program outcomes that are consistent with the Agency's investment in MI's. These award categories are:

• **Institutional Science, Engineering and Technology (SET) Awards** include the University Research Center Program (URC) and the Institutional Research Awards (IRA). The URC Awards are collaborative programs conducted in cooperation with each Strategic Enterprise. These awards are designed to achieve a broad-based, competitive aerospace research capability among the Nation's MI's that will: foster new aerospace science and technology concepts; expand the Nation's base for aerospace research and development; develop mechanisms for increased participation by faculty and students in mainstream research; and increase the productivity of students (who are U.S. citizens and who have historically been underrepresented) with advanced degrees in NASA-related fields. The URC's have formed a National Alliance of NASA University Research Centers (NANURC). This Alliance has established a National Conference of the University Research Centers, created pathways for developing greater collaborations between the URC's, and is exploring avenues for increasing the number of advanced degrees being awarded to disadvantaged students. NASA is strongly supportive of this concept and is actively working with the Alliance to further develop and strengthen their organization. In FY 2000, NASA established a URC Expert Review Panel to conduct an independent comprehensive review of the 10-year URC Program and findings are expected in mid-FY 2001. Since these awards have received satisfactory annual technical reviews from NASA researchers, the FY 2002 budget reflects NASA's intent to continue the Program. The continuation of the Program will take into consideration recommendations from the Expert Review Panel before issuing an announcement of opportunity for new University Research Centers.

Institutional Research Awards (IRA) improve academic, scientific and technology infrastructure and broaden the NASA-related science and technology base at MI's. The first IRA (Research) award was made in FY 1994 and was limited to only OMU's. The most recent competitively selected IRA awards were made in FY 2000 to both OMU's and an HBCU. These awards provide OMU's and HBCU's with an opportunity to provide a quality learning and research environment in NASA-related areas.

As a result of participating in this program, OMU's and HBCU's contribute directly to NASA research and human resources requirements; support the development of the institution's NASA-related research capabilities; and increase the number and percentage of underrepresented minorities who are U.S. citizens with advanced degrees in NASA-related fields.

All ISET award recipients receive technical direction from appropriate technical representatives of the NASA Strategic Enterprises. OEOP continues to maintain responsibility for program policy and oversight. In order to foster closer ties between the URC's, IRA's and NASA, a Lead NASA Center is designated for each award. This Center is responsible for directly managing the URC cooperative agreements and for increasing MI involvement in ongoing NASA research and development activities. Collaborations with other NASA Centers, industry, and other universities continue to be strongly encouraged.

• **Principal Investigators (PI) Awards** are designed to increase the participation of faculty and other professionals in conducting NASA research, research training and/or administration. Faculty and other professionals can apply to three different programs.

The Faculty Awards for Research (FAR) provide new faculty, and those who have limited NASA experience, the opportunity to integrate the research and education components of their careers with the unique mission requirements of a specific NASA

Center/JPL. The FAR program provides merit selection of proposals from outstanding and promising science, engineering, and technology (SET)-tenured and tenure-track faculty who are capable of contributing to the Agency's research and education objectives. This award provides faculty members with research support and exposure to the NASA peer review process to enable them to demonstrate creativity, productivity, and future promise in the transition to achieving competitive awards in the Agency's mainstream research processes. The primary strategy for implementing FAR is through a competitive peer review and merit selection process in collaboration with the NASA Centers/JPL. Other strategies include: (1) Maintaining discipline-related personnel at the NASA Centers/JPL who are responsible for serving as points-of-contact for faculty interested in pursuing an award in this category; (2) Invite NASA Centers/JPL to serve on technical peer review panels and to make selection recommendations to Headquarters for funding consideration; and (3) Hold the NASA Center/JPL responsible for management and monitoring the research outcomes. By involving MI faculty and students in NASA research, the Agency hopes to increase the interest of traditionally underrepresented communities in the Agency's mission and involve a broader array of America's citizenry in the NASA-sponsored research community. A thorough analysis of the program from its inception (FY 1992) through FY 2000 was conducted by an external review panel in FY 2000. The results showed that the program has had a positive impact on the faculty and students at the receiving institutions. A recommendation to solicit proposals from faculty in two categories: 1) junior faculty and 2) other faculty was accepted and incorporated into the FY 2001 program design. Proposals will be solicited in FY 2001 and FY 2002 and 30 new awards will be competitively selected each year.

The NASA Administrator's Fellowship Program (NAFP) provides opportunities for NASA career employees and the mathematics, science, engineering, and technology (MSET) faculty of minority-serving institutions to compete through peer review for placement in a formal professional development program. In addition to individualized professional development enhancement, NASA employees spend a year teaching or conducting research at a minority-serving institution while MSET faculty spends a year conducting research at a NASA Center.

The Louis Stokes Leadership Program provides competitive, peer review selection of faculty, educators and other scientific and technical personnel with an opportunity to participate in a 4-year professional leadership program designed to assist the HBCU's and OMU's in strengthening the delivery and management of NASA-sponsored scientific research, (MSET) educational and training programs. Participants will spend 2 years at a NASA Center/JPL and 2 years at an HBCU or OMU enhancing their knowledge and ability to lead the institutions in better responses to the Federal Financial Assistance Management Improvement Act, Electronic Grants Initiatives, the Government Performance and Results Act, and achievement of better performance outcomes in conducting NASA-funded research and education programs.

• **Mathematics and Science Education (MSE) Awards** build upon these institutions' outstanding ability to provide excellence in MSET training while increasing the participation and achievement of socially and economically disadvantaged and/or disabled students in MSET fields at all levels of education. Awards are made in the following three areas: undergraduate and graduate; teacher preparation and enhancement; and precollege activities.

MSE Awards contribute to the national education goals by integrating the contents from the NASA mission into the educational outreach projects at MI's. As a result, NASA contributes to the increase in the number and the strengthening of the skills, knowledge, and interest of students and teachers in mathematics-, science-, engineering-, and technology-based academic programs. New competitive peer review and merit selection awards will be made in the following areas during FY 2001 and FY 2002 to address NASA's future human resources requirements.

- Undergraduate and Graduate Awards provide scholarships, fellowships, internships, and research opportunities in NASA-related fields, and other services to enhance retention and increase graduation rates. These awards contribute to the U.S. scientific and technical leadership by partnering with HBCU's and OMU's to meet the Agency's mission and human resource requirements. They also respond to congressional direction to encourage students, particularly the underserved, to develop exceptional scholarship in science, mathematics, engineering and technology through research-based academic programs that increase the number of individuals from underrepresented groups in the pool of graduate researchers. In FY 2000, a NASA research-based fellowship program was established to address Congressional concerns about the underrepresentation of African Americans and other minorities in MSET areas. In FY 2001, at least 20 graduate students will enter the program and in FY 2002, NASA proposes to double the number of students to 40. All students must be U.S. citizens and must pursue degrees in NASA-related fields. During the academic year and/or summer, students are required to conduct research relevant to their fields of study at a NASA Center, on a university campus, at a Federal laboratory, or in the aerospace industry. It is expected that these students will form part of the pool from which NASA selects graduate researchers and/or employees.

- Teacher Preparation and Enhancement Awards provide opportunities for MI's to develop diverse and exemplary research-based mathematics, science, technology and geography teacher education curricula that are integrated with content from NASA's mission. It is the Agency's desire that the results will contribute to the participating states' efforts to increase the numbers and percentage of state-certified mathematics, science, technology or geography teachers employed in hard-to-staff elementary, middle, and secondary schools not normally served by NASA.

- Precollege Awards offer opportunities for MI's, in collaboration with NASA and local school districts, to provide informal educational opportunities that will enhance the numbers and percentage of students enrolled in mathematics and science college preparatory courses. As a result of participating in these awards, students will gain awareness of career opportunities in MSET fields, exposure to NASA's mission and scientific and technical personnel role models, and will enter college pursuing NASA-related career fields.

- **Partnership Awards** were continued in FY 2000 and FY 2001 with additional funds from Congress. These awards included the Partnership Awards for Innovative and Unique Research and Education Projects (IUREP) and the Partnership Awards for the Integration of Research into MSET Undergraduate Education (PAIR). These funds were also used to extend the Network Resources Training Sites awards for 3 additional years. To better measure program outcomes, beginning in FY 2001, the Partnership Awards for IUREP (Research) will be offered under the Principal Investigators Award category and the IUREP (Education) under the Mathematics and Science Education Awards category described above. In FY 2002, new Partnership Awards will be competitively selected to continue efforts to enhance academic infrastructure in specific NASA-related disciplines.

The NRTS will continue efforts to improve HBCU and OMU in-house capability to electronically access science data and computational resources; to develop mechanisms to support, sustain and evolve the network infrastructure of the targeted universities and colleges; and to make MI's more effective in the competitive process for NASA and other science, engineering and technology funding opportunities. IRA awards provide for the acquisition of equipment essential to Internet connectivity. The strategies for achieving the IRA goals include: (1) Establishing lead NRTS; (2) Holding the lead NRTS accountable for providing Internet connectivity to other MI's and public schools; and (3) Training students, faculty, and teachers to build computers and effectively utilize the Internet to compliment teaching and research collaborations and delivery. The lead NASA Center, Goddard Space Flight Center (GSFC), manages the IRA (NRTS) under the auspices of GSFC's Minority University-Space Interdisciplinary Network (MU-SPIN) Program. NASA Strategic Enterprises, NASA Centers, and JPL support NRTS programs through use of their facilities, and commitment of their personnel to serve on TRC's and by assisting in other facets of program implementation. Students and PI's involved in NRTS spend time on-site at the Centers/JPL throughout the year.

PAIR will continue in FY 2002 to have an interdisciplinary focus that spans more than one MSET academic program, creating a collaborative effort among different academic departments. To extend the interdisciplinary focus, the MI's are strongly encouraged to demonstrate in their proposals, partnerships with NASA Centers/JPL, other institutions of higher education, and with the aerospace community. This approach enables NASA to continue its efforts to enhance collaboration among MSET academic departments, thereby strengthening the MSET baccalaureate degree-producing capacity of a number of the Nation's HBCU's and OMU's by building upon previous NASA funding. As a result, the outcomes of partnership awards are: (1) innovative interdisciplinary study among MSET academic programs that center on NASA-related course study, research, and technological applications, including collaborative efforts within MSET academic departments; (2) more competitive undergraduate U.S. students, underrepresented in MSET fields who, because of their research training and exposure to cutting-edge technologies, are better prepared to enter MSET graduate programs or MSET employment; (3) enhanced undergraduate courses and curricula including laboratory-based curricula that foster collaborative educational experiences between faculty members and students leading to institutional faculty development efforts; and (4) model HBCU's and OMU's that integrate NASA-related research into the appropriate areas of the undergraduate curriculum that expose greater numbers of students and faculty to the Agency's cutting-edge technologies. To enhance better program outcomes in FY 2001, the PAIR awards were transferred to the NASA Centers for technical management and oversight.

In FY 2001, NASA entered into a partnership with the National Association for Equal Opportunity in Higher Education (NAFEO) to explore the possibility of establishing an Academy for Scientific Research and Educational Advancement in the NASA Ames Research Center Research Park. In FY 2002, NAFEO and partners from HSI's and TCU's will solidify their partnership with NASA and begin to 1) expand research collaborations between NASA and Research Park scientists both on-site and at the partnering institutions, especially in the areas of astrobiology/biotechnology, information technology and nanotechnology; 2) contribute with innovative novel projects designed to examine the new frontiers in space research; 3) focus on integrating faculty and students to current NASA projects and in encouraging them to pursue careers in fields related to NASA interests; and 4) establish a virtual community of faculty and students at HBCU's and OMU's dedicated to supporting NASA's scientific mission including a diverse scientific workforce.

SCHEDULE & OUTPUTS

MUREP metrics are continually being improved. Performance data measuring participation and program outcomes is obtained through the required submission of annual performance reports and/or on-site or reverse-site reviews of each grant. Each award recipient submits an annual performance report that is reviewed by a NASA Technical Monitor or a TRC for qualitative and quantitative progress toward the project's and NASA's program goals and objectives. Continuous assessment of this data has enabled OEOP MUREP to identify performance measures for research and education awards. As part of the grantee's annual reporting requirements, each awardee is now being required to respond to a set of uniform research or education outcomes that enables OEOP to assess progress across all research or education awards. The Uniform Outcomes Report was also designed to avoid duplication of reporting requirements by serving as the grantees' annual performance report. Additionally, as required by Executive Order 12876 for HBCU's, Executive Order 12900 for Educational Excellence for Hispanic Americans (EEHA), and Executive Order 13021 for TCU's, at the end of each fiscal year, NASA measures its performance against the concluding fiscal year plans that were submitted to the White House Initiative Offices and the Office of Management and Budget. The measures of performance include the number of awards and funding to HBCU's, EEHA's, and TCU's in the following categories: research and development; program evaluation; training; facilities and equipment; fellowships, internships, traineeships, recruitment and IPA's; student tuition assistance, scholarships, and other aid; direct institutional subsidies; third-party awards; private-sector involvement; and administrative infrastructure. The objectives are to establish uniform outcomes for all NASA MUREP awards and provide compact instruments for uniform collection of data keyed to those outcomes. This process reduces the collection of data to the minimal amounts possible, emphasizes outcomes, and is applicable to any common set of awards. The data collected can be aggregated both horizontally and longitudinally, permits adjustable benchmarking standards to be applied, and is collected electronically over the World Wide Web. A single annual collection of data is used to provide the information necessary for comparative and correlational analysis across research or education projects and information contained in the annual MUREP performance reports, including those required by the White House Initiative Offices on HBCU's, EEHA's, and TCU's. Based on prior years' evaluation results, the following uniform measures of performance have been established for OEOP MUREP research and education awards.

RESEARCH MEASURES OF PERFORMANCE (for URC's, IRA's, PI's, and Partnership (Research) Awards)

- Participants - students, faculty, post-doctoral researchers, research associates supported
- Student Outcomes - degrees awarded, post-graduation plans
- Research Outcomes – referred papers, technical presentations, patents, commercial products, research funds leveraged from other sources

EDUCATION AND TRAINING MEASURES OF PERFORMANCE (for MSE's and Partnership (Education) Awards)

- Participants - students, teachers supported
- High School Student Outcomes - enrollment in Mathematics, Science, Education and Technology (MSET) courses, graduation, enrollment in college, and selection of MSET majors
- Bridge Student Outcomes - completed freshman year in college
- Undergraduate and Graduate Student Outcomes - degrees awarded, post-graduation plans
- Teacher Outcomes - received certificates

IRA (NRTS) Additional metrics are designed to capture the technology and education focus of these awards. Specific metrics will include:

- The number of HBCU's, OMU's, and public schools connected to the Internet
- The number of faculty, teachers, and students trained to utilize the Internet to enhance research and educational outcomes

Continuous assessment of performance through annual evaluations of individual awards and the collection of uniform outcomes across all research and education programs will clearly indicate the impact of NASA MUREP on the scientific and technological base for NASA and the Nation, while minimizing the reporting burden on award recipients.

ACCOMPLISHMENTS AND PROPOSED RESULTS

NASA's MUREP investment in MI's for FY 2000 achieved the following:

1. Funding reached 39 states, the District of Columbia, the Virgin Islands, and Puerto Rico.
2. The number of awards involving competitive peer-review and merit-selection totaled 230 in FY 2000.
3. 77 HBCU's were involved in 206 research and education awards.
4. 73 OMU's were involved in 150 research and education awards.
   - 44 HSI's were involved in 88 research and education awards.
   - 19 TCU's were involved in 10 research and education awards.
   - 43 other institutions of higher education were involved in MUREP-funded awards.
   - 16 educational/professional organizations and 10 other organizations such as the American Association for the Advancement of Science, National Association for Equal Opportunity in Higher Education, National Action Council for Minorities in Engineering, Hispanic Association of Colleges and Universities, the Society for the Advancement of Chicanos and Native Americans in Science, the American Society for Engineering Education, and National Research Council were involved in MUREP-funded awards.

Described below are the accomplishments of the Research Measures of Performance and the Education and Training Measures of Performance. The outcomes reported for FY 2000 (reporting period Summer 1999 and Academic Year 1999-2000) show the following achievements for underrepresented and underserved students, teachers, and faculty.

<u>Research Measures of Performance Accomplishments.</u> The participants included 408 faculty members, 101 research associates, 32 postdoctoral fellows, 783 undergraduates, and 406 graduates. The MI's were able to leverage their NASA MUREP funding of $27 million to an additional $36.2 million in research support ($6.7 million from other NASA programs and $29.5 million from other agencies). Technology transfer activities included 32 patents disclosed, applied for, or awarded and 20 commercial products being developed or marketed. A major goal of MUREP is to increase the number of socially and economically disadvantaged and disabled students receiving advanced degrees and entering into careers in NASA-related fields. Of the 1,189 students involved in these research projects during the reporting period, 783 (66%) participated at the bachelors degree level, 294 (25%) participated at the masters degree level, and 112 (9%) participated at the doctoral degree level. During the reporting period, 416 students obtained degrees; 293 bachelor's degrees; 104 master's degrees; and 19 doctoral degrees.

<u>Education and Training Measures of Performance Accomplishments.</u> There were 157 MUREP education and training projects conducted at MI's. The programs included precollege and bridge programs, education partnerships with other universities, industry and nonprofit organizations, NRTS, teacher training, and graduate and undergraduate programs. These programs reached a total of 52,369 participants, with the predominant number at the precollege level. The programs achieved major goals of heightening students' interest and awareness of career opportunities in MSET fields and exposing students to the NASA mission, research and

advanced technology through role models, mentors, and participation in research. Formats included Saturday Academies, after-school classes, visits to NASA Centers and other scientific and technical industries, museums, hands-on science experiments, and computer training. Grantees reported that 15,190 high school students participated in NASA programs and 3,460 high school students selected college preparatory MSET courses. There were 1,969 high school graduates and 181 bridge students (high school graduates) in NASA programs. Enrolled in college were 1,274 students, of which 616 selected MSET majors. There was 146 High School Bridge students from Academic Year 1998/1999 who successfully completed the freshman year. For the teacher programs, 2,773 teachers (614 preservice teachers and 2,159 inservice teachers) participated and 803 teachers received certification (61 preservice and 742 inservice). For undergraduate student programs, 9,956 students participated, and 1,182 received degrees. There were 744 graduate students participating in graduate programs, and 152 received degrees. There were 77 papers published, 56 of which were authored or co-authored by students. There were 60 presentations given at NASA Centers/JPL and 214 presentations at national or international conferences.

• **NASA Strategic Enterprises and the Office of Equal Opportunity Programs Partnerships with HBCU's and OMU's** continued in FY 2000 and FY 2001. In FY 2000, the Enterprises invested $28.8M and in FY 2001, $36.2M in URC's, IRA's, and other programs and activities at MI's and other educational organizations. For FY 2002, these encumbered funds have been included in this portion of the Agency's budget. Additional collaborations between the OEOP and with each of the NASA Strategic Enterprises in FY 2000 and FY 2001 included jointly sponsored NASA Research Announcements that included opportunities for HBCU's and OMU's to compete and be selected through the peer review process for funding that will develop their research and education capabilities in areas specific to the mission of the partnering Strategic Enterprise. During FY 2000, several opportunities resulted from the OEOP and Strategic Enterprises' collaborative efforts. Initiatives with two of the five Enterprises are described below.

The Office of Earth Science (OES) and OEOP made awards from the competitive Earth Science Education initiative in FY 2000. OES solicited proposals from a broad range of education and research professionals to develop and implement Earth System Science Education Programs targeted for kindergarten through postdoctoral levels. Two HBCU's and a TCU received awards under this initiative.

Also in FY 2000, OEOP collaborated with OES on the UnESS Project. The Project was established to foster the development of the next generation of Earth system scientists, engineers, managers, educators, and entrepreneurs through significant and meaningful hands-on student involvement in Earth observation space missions at the university level. Applicants were required to include significant student involvement and were strongly encouraged to include the participation of MI's in their missions. OEOP provided supplemental funding to the top-rated scientific proposals that included significant and meaningful participation by HBCU's and OMU's. The purpose of the OEOP funding was to facilitate partnerships between NASA-funded institutions of higher education with substantial Agency assets and with HBCU's and OMU's that would lead to genuine investments in the NASA mission and long-term benefits to the individual HBCU or OMU. Nine HBCU's and OMU's received awards under this initiative.

In FY 2002, OEOP and OES will jointly sponsor a NASA Research Opportunity that will emphasize strengthening HBCU and OMU Earth Science academic infrastructure to enable these institutions to better respond to Earth Science investigations and technical personnel requirements.

The Office of Space Science (OSS)/OEOP Minority University Education and Research Partnership Initiative Program in Space Science provided opportunities for enhancing minority colleges and universities' study of Space Science and an understanding of the role of research in this field. The goals of the 3-year education and research awards are: (1) the development of Space Science-related academic capabilities and programs at MI's; and (2) the enhancement/development of faculty and students in Space Science-related fields at MI's through the establishment of partnerships and exchange programs in research and education with NASA-supported Space Science research groups. Fifteen HBCU's and OMU's were competitively selected in FY 2000 for 3-year awards.

SUMMARY

In FY 2001, NASA MUREP will continue to focus on its goals and strategies to integrate mission-focused research, technology transfer, and education at HBCU's and OMU's. NASA will continue to emphasize partnership awards that leverage NASA's investment by encouraging collaboration among NASA, HBCU's, OMU's and other university researchers and educators, and the aerospace industry. The Agency is also planning for new awards in
FY 2002 to include PI's, Math and Science, and Partnership awards.

BASIS OF FY 2002 FUNDING REQUIREMENT

HISTORICALLY BLACK COLLEGES AND UNIVERSITIES

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Historically Black Colleges and Universities	35,900	36,377	48,900
Institutional Science, Engineering and Technology Awards		3,483	11,544
Principal Investigator Awards	6,429	4,445	7,650
Math and Science Education Awards	20,894	14,429	18,180
Partnership Awards	8,577	14,020	11,526
Enterprise Program Funding *	[17,200]	[20,900]	[--]

* $20,900-increase in FY 2002 represents encumbered funding previously included in the Enterprise budgets.

PROGRAM GOAL

NASA's HBCU program is responsive to Executive Order 12876, which requires all Federal agencies to strengthen the capacity of HBCU's to provide quality education and to participate in and benefit from Federal programs. The primary goal of NASA's HBCU program is to enhance institutional infrastructure in NASA-related areas and to provide technical assistance to facilitate planning, development, and the use of new technologies that will ensure the long-term viability and educational outcomes of HBCU's in areas strategic to NASA's mission.

STRATEGY FOR ACHIEVING GOALS

HBCU's were involved in NASA's mission before man set foot on the Moon in 1969. In 1980, President Jimmy Carter signed Executive Order 12232 which established a Federal program "…to strengthen and expand the capacity of HBCU's to provide quality education." Executive Orders issued by Presidents Ronald Reagan and George Bush strengthened this program. NASA's current initiatives for HBCU's are based on two recent Executive Orders. Executive Order 12876, signed November 1, 1993, by President William J. Clinton, mandates that agencies "…advance the development of human potential, to strengthen the capacity of HBCU's to participate in and benefit from Federal programs to achieve an increase in the participation by HBCU's in Federal programs." Executive Order 12928, signed February 16, 1994, by President Clinton, directs Federal agencies to promote procurement with "…Historically Black Colleges and Minority Institutions." NASA employs a comprehensive strategy to accomplish the HBCU program goals.

ACCOMPLISHMENTS AND PROPOSED RESULTS

As a result of NASA's FY 2000 investment in HBCU's, 30 HBCU's were the recipients of 204 awards which reached more than 20,428 faculty, teachers, and students. The FY 2002 budget estimate includes funding to continue HBCU involvement in all five award categories. Specific accomplishments for each of the categories are as follows:

HBCU	**FY 2000 Accomplishments**	**University Research Centers**	**Principal Investigators**	**Partnership Awards**
	Research Population Supported:	519	245	325
	Faculty Members	137	44	81
	Research Associates	30	15	15
	Postdoctoral Fellows	12	1	62
	Bachelors-Degree Level Students	207	135	134
	Masters-Degree Level Students	89	43	26
	Doctoral-Degree Level Students	44	7	7
	Degrees Awarded:	118	62	48
	Bachelors Degrees	76	42	42
	Masters Degrees	31	19	5
	Doctoral Degrees	11	1	1
	% Socially/Economically Disadvantaged or Disabled	88%	84%	98%
	Research Accomplishments:			
	Refereed Papers or Book Chapters:			
	Published	216	35	41
	Student (Co) Authors to above	111	14	33
	Accepted for Publication	86	11	15
	Student (Co) Authors to above	38	4	16
	Technical Presentations:			
	Total Presentations	**316**	**94**	**81**
	Presentations given by Students	125	37	44
	Leverage Achieved (in $M):			
	Funding Provided by MUREP	$10.7	$2.7	$3.3
	Leverage from Other NASA Programs	$5.4	$0.1	$0.2
	Leverage from Other Agencies	$14.4	$0.9	$2.4
	Technology Transfer Activities:			
	Patents disclosed, applied for, or awarded	6	4	1
	Commercial products being developed or marketed	3	4	2
	Grant Awards Reporting	11	50	33

HBCU Institutional SET Awards (URC Awards)

Eleven HBCU URC's were established by the Headquarters Office of Space Science (OSS), Office of Aerospace Technology (OAT), Office of Space Flight (OSF), Office of Biological and Physical Research (OBPR), Office of Earth Science (OES), and the Office of Equal Opportunity Programs (OEOP). Funding is provided in two stages and the capability of the university determines the amount. In the first stage, more funding is provided to establish a research infrastructure capable of sustaining long-term success in their research and education efforts (up to $2M per university). Based on the URC Program Plan, the funding is reduced in the second stage (not to exceed $1M per university) to recognize and encourage the movement of the URC's towards self-sufficiency through other funding sources. Funding for the following HBCU URC's was provided by the Strategic Enterprises in FY 2000 and FY 2001. In FY 2002, these funds have been placed in this budget.

University	Research Focus	Enterprises	Lead Center
Clark Atlanta	High Performance Polymers and Composites Research	OAT	GRC
Fisk	Photonic Materials and Devices	OSS	MSFC
Florida A&M	Nonlinear and Nonequilibrium Aeroscience	OAT	LaRC
Hampton	Optical Physics	OSS, OES	LaRC
Howard	Study of Terrestrial and Extraterrestrial Atmospheres	OSS, OES	GSFC
NC A&T State	Aerospace Research	OAT	LaRC
Tuskegee	Food and Environmental Systems for Human Exploration of Space	OAT	JSC
Alabama A&M	Hydrology, Soil Climatology, and Remote Sensing	OES	MSFC
Morehouse School of Medicine	Space Medicine and Life Sciences	OBPR	JSC
Prairie View A&M	Applied Radiation Research	OSF	JSC
Tennessee State	Automated Space Science	OSS	GSFC

HBCU Institutional SET Awards (Institutional Research Awards [IRA])

In FY 2001, HBCU's were invited to participate in the IRA (Research) program for the first time. The IRA (Research) goals include: (1) strengthening and improving core research areas of significance to the NASA mission; (2) increasing the number of students (who are U.S. citizens) conducting space research and working in NASA-related disciplines; (3) strengthening the research environment of eligible institutions and the capability of individuals by supporting the institutional infrastructure (through the acquisition of research equipment), faculty research, and disadvantaged undergraduate and graduate student researchers; and (4) encouraging technology transfer to the market place and to minority communities. To achieve these objectives, an Agencywide TRC is assigned to each of the selected IRA (Research) award recipients and is responsible for providing technical guidance. NASA promotes collaboration between its funded IRA institutions, the Centers/JPL, and with entities outside of NASA. Institutions are encouraged to seek funding through NASA's traditional opportunities, as well as other government agencies and private sources to promote future sustainability. IRA awards require substantial undergraduate and graduate student involvement in research projects.

In FY 2001, OAT and OSS provided funding for the new IRA (Research) Awards. Funds previously held in the Enterprises' budgets will reside in the OEOP FY 2002 MUREP budget and will provide second-year funding for the 2 HBCU IRA's.

HBCU Principal Investigator (PI) Awards

Faculty Awards for Research (FAR) grants provide for research and student support and exposure to the NASA peer review process to enable faculty to demonstrate creativity, productivity, and future promise in the transition to achieving competitive awards in the Agency's mainstream research activities. In FY 2000, funding was provided for 44 third-year awards. In FY 2001, continuation funding was provided for 20 awards. There were no new awards due to the conduct of the third party FAR program evaluation. In FY 2002, funding will be continued for 9 awards and 10 new awards will be selected through the competitive peer review process.

In FY 2000, the NAFP Fellows participated at three HBCU's including Bennett College, Texas Southern University, and Howard University. FY 2001 Fellows participated at six HBCU's including Hampton University, Texas Southern University, Prairie View A&M University, Spelman College, Alabama A&M University and Norfolk State University. In FY 2002, eight HBCU's are expected to participate in the NAFP.

HBCU Math and Science Education Awards

The Math and Science Education Awards are composed of unsolicited awards and awards made based on solicitations. Primary funding supports the following four focus areas: undergraduate awards; graduate awards; precollege awards; and teacher enhancement and preparation awards.

During the FY 2000 reporting period (Summer 1999 and Academic Year 1999/2000), 80 MUREP education and training projects were conducted at HBCU institutions. The programs included precollege and bridge programs, education partnerships with other universities, industry and nonprofit organizations, NRTS, teacher training, and graduate fellows and/or undergraduate programs. These programs reached a total of 19,402 participants, with the predominant number at the precollege level. The programs achieved major goals of heightening students' interest and awareness of career opportunities in MSET fields, and exposing students to the NASA mission, research and advanced technology through role models, mentors, and participation in research and other educational activities. Grantees reported 6,834 high school students in NASA programs and 670 high school students selected college preparatory MSET courses. There were 1,379 high school graduates, 719 enrolled in college, and 101 selected MSET majors. There were 161 prior year high school graduates (bridge students) in NASA programs and 128 students who successfully completed their freshman year. There were 1,822 teachers in teacher programs and 725 teachers received certificates. For undergraduate student programs, 2,859 students participated and 164 received degrees. There were 88 graduate students reported in the survey and 8 received degrees. There were 31 papers published, 17 of which were authored or co-authored by students. There were 33 presentations given at NASA Centers and 141 presentations at national and international conferences.

The FY 2001 Appropriations Bill for VA-HUD-Independent Agencies provided additional funding for NASA to make awards to Morgan State University ($1.6M), Texas College ($1.0M), and Spelman College ($1.0M). The across-the-board .038-percent rescission resulted in these additional amounts being decreased as follows: $1.464M to Morgan State University, $0.915M to Texas

College, and $0.915M to Spelman College. In FY 2001, funding was provided for 6 Mathematics, Science and Technology Awards for Teacher and Curriculum Enhancement Program (MASTAP) awards and 17 PACE awards. Funding will continue for PACE and MASTAP awards, and new HBCU educational awards will be selected in FY 2001 and FY 2002 to replace expiring awards.

Additionally, in an effort to be responsive to congressional direction to "strengthen graduate science, mathematics, engineering, and technology education at HBCU's" and to address the severe underrepresentation of African Americans at the doctoral level, NASA started a 5-year predoctoral fellowship program in FY 2000. A minimum of 10 graduate students will be selected in FY 2001 and funding continued in FY 2002. New selections will also be made in FY 2002.

HBCU Partnership Awards

In FY 2000, the 42 competitively awarded Partnership Awards for Innovative and Unique Education and Research (IUER) Projects continued at HBCU's located in 11 states and the District of Columbia received continuation funding and their last year of funding in FY 2001. In FY 2002, new awards will be selected under the Principal Investigator Awards and Mathematics and Science Awards categories. Four Partnership Awards for the Integration of Research into Undergraduate Education (PAIR) continued for the third year of the 5-year awards. Two new (PAIR) awards were competitively awarded to HBCU's (Norfolk State University and South Carolina State University). In FY 2002, a new solicitation will be issued to replace the four expiring HBCU awards. Two HBCU PAIR awards will receive their third year of funding

In FY 2002, HBCU's will continue to participate in and contribute to the establishment of the NASA/NAFEO Academy for Scientific Research and Educational Advancement at Ames Research Center.

HBCU Partnerships with NASA Strategic Enterprises and the Office of Equal Opportunity Programs

Office of Earth Science--Two HBCU's received three 3-year awards from the jointly sponsored OES and OEOP competitive Earth Science Education initiative in FY 2000 (1 to Norfolk State University and 2 to Elizabeth City State University). Second-year funding was provided in FY 2001 and will be continued during the final funding year,
FY 2002. Also, in FY 2000 two HBCU's (Alabama A&M University and Howard University) were selected to participate in the 1-year UnESS Project, "Concept Study Phase.

Office of Space Science--In FY 2000, the OSS/OEOP Minority University Education and Research Partnership Program competitively selected six HBCU's to participate in the Minority Institution Initiative. The first year of the planned 3-year funding was initiated in FY 2001. The second year of funding will occur in FY 2002. The six award recipients were: Norfolk State University, Hampton University, Florida A&M University, Alabama A&M University, Southern University A&M, and South Carolina State University.

In FY 2001, the 42 Partnership (IUER) Awards will receive second-year funding and the 4 PAIR Awards will receive third-year funding. In FY 2002, the 5 PAIR Awards will receive continuation funding. New awards to enhance the MSET infrastructure in NASA-related disciplines will be competitively selected in FY 2001 and FY 2002.

BASIS OF FY 2002 FUNDING REQUIREMENT

OTHER MINORITY UNIVERSITIES (OMU)

	FY 2000	FY 2001	FY 2002
		(Thousands of Dollars)	
Other Minority Universities	17,900	19,500	33,200
Institutional Science, Engineering and Technology Awards		3,063	11,563
Principal Investigator Awards	3,500	1,119	2,269
Math and Science Education Awards	11,300	11,300	15,303
Partnership Awards	3,100	4,018	4,065
Enterprise Program Funding *	[11,600]	[15,300]	[--]

* $15,300-increase in FY 2002 represents encumbered funding previously included in the Enterprise budgets.

PROGRAM GOAL

The primary goal of NASA's OMU program is to increase the opportunities for HSI's, TCU's, and educational organizations serving substantial numbers of people with disabilities to participate in and benefit from NASA's research and education programs.

STRATEGY FOR ACHIEVING GOALS

NASA established the OMU program per P. L. 98-371, House Report 98-803, and Senate Report 98-506 to "...review institutions of higher learning having significant minority enrollments to find ways to build closer relations with such schools, meet NASA's research objectives and increase the number of individuals from underrepresented groups in the pool of graduate researchers ...build a closer relationship with institutions serving significant numbers of minorities." In addition, Executive Order 12900 (February 22, 1994) mandated that agencies increase Hispanic American participation in Federal education programs in which Hispanic Americans currently are underserved; Executive Order 12928 (September 16, 1994) directed Federal agencies to promote procurement with "...Historically Black Colleges and Minority Institutions;" and P.L. 103-327 directed the establishment of URC's at the HSI's. Executive Order 13021 (October 19, 1996) directed Federal agencies and departments to strengthen their relationships with TCU's. In response, NASA is developing a 5-year plan of action and submitted its first annual accomplishment report to the White House Initiative Office for Tribal Colleges. Present awards to TCU's are encouraged within the five programmatic awards.

Although similar to the HBCU Program strategies and because of the differences in the evolution of MI's and the particularities of Federal mandates for HBCU's and Hispanic Americans, NASA's approach and implementation plan have been adjusted to incorporate these factors. For example, the Federal mandate for Hispanic Americans directs Federal agencies to "....improve educational outcomes for Hispanic Americans participating in Federal education programs...". As a result, the Agency has placed greater emphasis on mathematics and science awards than on institutional research awards.

ACCOMPLISHMENTS AND PROPOSED RESULTS

As a result of NASA's FY 2000 investment in OMU's, 132 OMU's, non-profit educational organizations and other institutions were involved in 77 research and education awards which reached more than 32,627 faculty, teachers, and students. Specific accomplishments for each of the categories are as follows:

FY 2000 Accomplishments	**University Research Centers**	**Institutional Research Awards**	**Principal Investigators**	**Partnership Awards**
Research Population Supported:	209	191	166	54
Faculty Members	53	35	27	16
Research Associates	12	21	1	4
Postdoctoral Fellows	1	10	5	0
Bachelors-Degree Level Students	74	72	94	15
Masters-Degree Level Students	54	33	29	15
Doctoral-Degree Level Students	15	20	10	4
Degrees Awarded:	61	27	60	12
Bachelors Degrees	36	17	48	5
Masters Degrees	22	7	12	7
Doctoral Degrees	3	3	0	0
% Socially/Economically Disadvantaged or Disabled	87%	85%	82%	100%
Research Accomplishments:				
Refereed Papers or Book Chapters:				
Published	68	69	25	6
Student (Co) Authors to above	45	32	41	7
Accepted for Publication	59	33	14	8
Student (Co) Authors to above	35	24	11	12
Technical Presentations:				
Total Presentations	188	124	59	29
Presentations given by Students	103	41	47	15
Leverage Achieved (in $M):				
Funding Provided by MUREP	$2.8	$2.5	$1.9	$0.4
Leverage from Other NASA Programs	$0.3	$0.3	$0.2	$0.1
Leverage from Other Agencies	$5.3	$2.7	$3.1	$0.2
Technology Transfer Activities:				
Patents disclosed, applied for, or awarded	8	10	3	0
Commercial products being developed or marketed	4	5	0	2
Grant Awards Reporting	3	5	28	10

OMU Institutional SET Awards (URC)

Three OMU URC Awards were established by Headquarters OSS, OAT, OSF, OES, and OEOP. Funding for the following OMU URC's were provided by the Strategic Enterprises in FY 2000 and FY 2001. In FY 2002, funds for these awards reside in this budget.

University	Research Focus	Enterprises	Lead Center
New Mexico	Autonomous Control Engineering	OAT	ARC
Texas at El Paso	Pan American Center for Earth and Environmental Studies	OES	GSFC
Puerto Rico at Mayaguez	Tropical Center for Earth and Space Sciences	OSS, OES	GSFC

OMU Institutional SET Awards (IRA)

The IRA (Research) goals include: (1) strengthening and improving core research areas of significance to the NASA mission; (2) increasing the number of students who are U.S. citizens conducting space research and working in NASA-related disciplines; (3) strengthening the research environment of eligible institutions and the capability of individuals by supporting the institutional infrastructure (through the acquisition of research equipment), faculty research, and disadvantaged undergraduate and graduate student researchers; and (4) encouraging technology transfer to the market place and to minority communities. To achieve these objectives, an Agencywide TRC is assigned to each of the selected IRA (Research) award recipients and is responsible for providing technical guidance. The IRA (NRTS) grants offer advanced computer networking infrastructure and technologies to other institutions of higher education and schools with substantial enrollments of socially and economically disadvantaged and/or disabled students in their regions. These institutions are responsible for information dissemination sites, development of faculty and student network skills, and user working groups. NASA promotes collaboration between its funded IRA institutions, the Centers/JPL, and with entities outside of NASA. Institutions are encouraged to seek funding through NASA's traditional opportunities, as well as other government agencies and private sources to promote future sustainability. IRA awards require substantial undergraduate and graduate student involvement in research projects.

In FY 2000 and FY 2001, OSS, OES, and OAT continued to fund 5 OMU IRA (Research). In FY 2002, funding for the following awards will be funded under this budget. In FY 2001, OMU's will have an opportunity to compete for NASA URC awards. These awards will be made early in FY 2002.

University	Research Focus	Enterprises	Lead Center
IRA (Research):			
California State-Los Angeles	Use of Decentralized Control in Design of a Large Segmented Space Reflector	OSS	JPL
Florida International	High Performance Database Management with	OES	GSFC

	Application to Earth Sciences		
Puerto Rico at Rio Piedras	Land Management in the Tropics and its Effects on the Global Environment	OES	MSFC
City College of New York	Tunable Solid State Laser and Optical Imaging	OAT	LaRC
New Mexico Highlands	Alliance for Nonlinear Optics	OAT	MSFC
IRA (NRTS):			
City College of New York	Urban Collaboration for Network Connectivity and Internet Access	OSS, OES	GSFC
Texas at El Paso	Network Resources Training Sites	OSS	GSFC

OMU Principal Investigators (PI) Awards

Faculty Awards for Research (FAR) provide for research and student support and exposure to the NASA peer review process to enable faculty to demonstrate creativity, productivity, and future promise in the transition to achieving competitive awards in the Agency's mainstream research activities. In FY 2000, funding was provided for 29 awards. In FY 2001, continuation funding was provided for 13 awards. New awards will be selected in FY 2001 and FY 2002.

In FY 2000, an NAFP Fellow conducted research training at the University of Puerto Rico-Humacao. In FY 2001, NAFP Fellows were located at two OMU's, New Mexico State University and the University of Puerto Rico-Rio Piedras. In FY 2002, NAFP Fellows are expected to be involved with at least four OMU's.

OMU Mathematics and Science Education Awards

The Math and Science Education Awards support the following four focus areas: undergraduate awards; graduate awards; precollege awards; and teacher enhancement and preparation awards. New awards will be competitively selected in FY 2001 and FY 2002.

During the FY 2000 reporting period (Summer 1999 and Academic Year 1999-2000), 109 MUREP education and training projects were conducted at OMU institutions. The institutions conducted precollege and bridge programs, education partnerships with other universities and industry, NRTS, teacher training, and graduate and undergraduate programs. These programs reached a total of 24,263 participants, predominantly at the precollege level and achieved major goals of heightening students' interest and awareness of career opportunities in MSET fields, and exposing students to the NASA mission, research and advanced technology through role models, mentors, and participation in research and other educational activities. Grantees reported 8,356 high school students in NASA programs and 2,790 high school students selected college preparatory MSET courses. There were 590 high school graduates, 555 enrolled in college, and 515 who selected MSET majors. There were 20 prior high school graduates (bridge students) in NASA programs and 18 students successfully completed the freshman year. There were 951 teachers in teacher programs and 78 teachers received certificates. There were 7,090 undergraduate students and 1,018 received undergraduate degrees in NASA-related fields. There were 645 graduate participants and 144 received graduate degrees in NASA-related fields. There were 43 papers published, 35 of which were authored or co-authored by students. There were 25 presentations given at NASA Centers and 66 presentations given at national and international conferences.

In FY 2000, 10 MASTAP, 32 PACE, and 10 SEMAA awards were continued. In FY 2001, 10 MASTAP, 22 PACE, and 10 SEMAA awards continued to be funded. A solicitation to competitively fund 4 new SEMAA sites was released. In FY 2002, 6 MASTAP, 11 PACE, and 14 SEMAA awards will continue to be funded.

OMU Partnership Awards

In FY 2000, 30 new Partnership Awards for Innovative and Unique Education and Research (IUER) Projects in eight states and Puerto Rico received continuation funding and their last year of funding in FY 2001. In FY 2002, new awards will be selected under the Principal Investigator Awards and Mathematics and Science Awards categories. Three Partnership Awards for the Integration of Research into Undergraduate Education (PAIR) received continuation funding. One new PAIR award (California State University at Northridge) was awarded a 4-year grant in FY 2000. In FY 2001, 4 PAIR awards will receive continuation funding. In FY 2002, a new solicitation will be issued to replace the 3 expiring OMU PAIR Awards. One OMU PAIR Award will receive third-year funding. New awards to enhance the OMU MSET infrastructure in NASA-related disciplines will be competitively selected in FY 2001 and FY 2002.

In FY 2002, OMU's, including HSI's and TCU's, will continue to participate in and contribute to the establishment of the NASA/NAFEO Academy for Scientific Research and Educational Advancement at Ames Research Center.

OMU Partnerships with NASA Strategic Enterprises and the Office of Equal Opportunity Programs

Office of Earth Science (OES)--One OMU, a Tribal College (Salish Kootenai College), received a 3-year award from the jointly sponsored OES and OEOP competitive Earth Science Education initiative in FY 2000. Second year funding was provided in FY 2001 and will be continued during the final funding year, FY 2002. Seven OMU's, including 3 HSI's (University of Puerto Rico at Mayaguez, California State University at Northridge, and Sul Ross University) and 4 other minority-serving institutions (Chicago State University, Medgar Evers College, City College of New York, and LaGuardia Community College) were selected to participate in the 1-year UnESS Project, "Concept Study Phase."

Office of Space Science (OSS)--In FY 2000, the OSS/OEOP Minority University Education and Research Partnership Program competitively selected nine OMU's to participate in the Minority Institution Initiative. The first year of the planned 3-year funding was initiated in FY 2001. The second year of funding will occur in FY 2002. The nine award recipients were the: University of Texas-El Paso, Eastern New Mexico University, University of Houston, York College, Southwestern Indian Polytechnic Institute, Salish Kootenai College, Dine College, Medgar Evers College, and the University of Hawaii at Hilo.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TWO APPROPRIATION BUDGET/MISSION SUPPORT

FISCAL YEAR 2002 ESTIMATES

GENERAL STATEMENT

In FY 2000 and FY2001, the Mission Support appropriation provided funding for mission support and includes: safety, mission assurance, engineering and advanced concepts activities supporting agency programs; salaries and related expenses in support of research in NASA field installations; design, repair, rehabilitation and modification of institutional facilities and construction of new institutional facilities; and other operations activities supporting conduct of agency programs.

Beginning in FY 2002, NASA is implementing a two-appropriation budget (excluding the Inspector General account). The two-appropriation budget includes Human Space Flight (HSF) and Science, Aeronautics and Technology (SAT) and is NASA's first step at transitioning to a full cost budget. While full cost will ultimately integrate institutional and programmatic funds into a single budget, that integration is done in a step-wise manner, by providing for a mission support budget line under each Enterprise and eliminating the present mission support appropriation. This initial step will begin to recognize, budget, and track direct full time equivalent (FTE) people associated at the Enterprise level and then use this FTE data to distribute other-than-direct (OTD) institutional costs (Research and Program Management and non-programmatic Construction of Facilities) using the relative percentages of direct FTE's by Enterprise.

This means the distribution of the OTD resources takes advantage of a basic assumption, to be used prior to the existence of cost and service pools, that FTE's are a reasonable relative indicator at the Enterprise level of required facility and institutional capabilities. Taking this step will help program/project personnel and decision makers begin to understand the potential magnitude of institutional funds that are associated with each Enterprise in preparation for the day when full cost budgeting will distribute these funds most appropriately to the project level via the appropriate cost/service pools.

The Mission Support budget is shown for display purposes only. Beginning in FY 2002, there will no longer be a Mission Support account. Institutional costs will be budgeted within HSF and SAT (as discussed above), and Safety, mission assurance and engineering will be budgeted within the HSF account

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TWO APPROPRIATION BUDGET/MISSION SUPPORT

FISCAL YEAR 2002 ESTIMATES
(IN MILLIONS OF REAL YEAR DOLLARS)

		BUDGET PLAN	
	FY 2000 OPLAN Revised	FY 2001 OPLAN Revised	FY 2002* PRES BUDGET
MISSION SUPPORT	**2,511.5**	**2,602.3**	**[2,740.5]**
SAFETY, MISSION ASSURANCE AND ENGINEERING	43.0	47.4	[47.8]
SPACE COMMUNICATIONS SERVICES	89.7	---	---
RESEARCH AND PROGRAM MANAGEMENT	2,199.7	2,275.4	[2,460.0]
CONSTRUCTION OF FACILITIES	179.1	279.5	[232.2]

**Beginning in FY 2002, SMA&E will be included within the Human Space Flight Appropriation. Research and Program Management and Construction of facilities will be included in the Institutional Support budgets in each of the five enterprises. FY 2002 data is for comparison purposes only.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TWO APPROPRIATION BUDGET/MISSION SUPPORT

REIMBURSABLE SUMMARY
(IN MILLIONS OF REAL YEAR DOLLARS)

	BUDGET PLAN		
	FY 2000 OPLAN Revised	FY 2001 OPLAN Revised	FY 2002* PRES BUDGET
MISSION SUPPORT	**113.5**	**76.0**	**---**
SAFETY, MISSION ASSURANCE AND ENGINEERING	0.1	0.3	--
SPACE COMMUNICATIONS SERVICES	61.3	--	--
RESEARCH AND PROGRAM MANAGEMENT	47.6	70.7	--
CONSTRUCTION OF FACILITIES	4.5	5.0	--

**Beginning in FY 2002, SMA&E will be included within the Human Space Flight Appropriation. Research and Program Management and Construction of facilities will be included in the Institutional Support budgets in each of the five enterprises.*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES

DISTRIBUTION OF MISSION SUPPORT BY INSTALLATION
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	Stennis Space Center	Ames Research Center	Dryden Flight Research Center	Langley Research Center	Glenn Research Center	Goddard Space Flight Center	Jet Propulsion Lab	Headquarters
Safety, Mission Assurance,	2000	43,000	7,142	914	1,760	80	6,193	334	5,124	2,501	8,761	6,958	3,233
Engineering, and	2001	47,396	7,625	360	2,962	150	1,105	300	5,925	2,298	15,349	7,368	3,954
Advanced Concepts	2002	0	0	0	0	0	0	0	0	0	0	0	0
Space Communications	2000	89,700	51,400	14,000	4,000	0	0	0	0	0	17,400	2,700	200
	2001	0	0	0	0	0	0	0	0	0	0	0	0
	2002	0	0	0	0	0	0	0	0	0	0	0	0
Research and Program	2000	2,199,744	340,254	250,759	312,221	44,370	182,185	61,488	231,185	200,052	374,950	399	201,881
Management	2001	2,275,375	366,020	247,671	326,630	43,622	192,042	63,690	237,240	210,224	376,487	270	211,479
	2002	0	0	0	0	0	0	0	0	0	0	0	0
Total Construction of	2000	179,100	17,538	32,492	21,344	9,930	11,901	7,216	19,845	19,396	19,780	14,372	5,286
Facilities	2001	279,481	33,451	48,802	32,232	45,397	21,559	5,825	17,952	29,800	24,213	16,898	3,352
	2002	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL MISSION SUPPORT	2000	2,511,544	416,334	298,165	339,325	54,380	200,279	69,038	256,154	221,949	420,891	24,429	210,600
	2001	2,602,252	407,096	296,833	361,824	89,169	214,706	69,815	261,117	242,322	416,049	24,536	218,785
	2002	0	0	0	0	0	0	0	0	0	0	0	0

TWO APPROPRIATION BUDGET/MISSION SUPPORT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SAFETY & MISSION ASSURANCE
OFFICE OF THE CHIEF ENGINEER
OFFICE OF THE CHIEF TECHNOLOGIST

SAFETY, MISSION ASSURANCE, ENGINEERING AND ADVANCED CONCEPTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002* PRES BUDGET
		(Thousands of Dollars)	
Safety and Mission Assurance	25,200	25,145	[28,700]
Engineering	13,100	17,462	[19,100]
Advanced Concepts	4,700	4,789	--**
Total	43,000	47,396	[47,800]

Distribution of Program Amount by Installation

Johnson Space Center	7,142	7,625	[8,645]
Kennedy Space Center	914	360	[550]
Marshall Space Flight Center	1,760	2,962	[3,700]
Stennis Space Center	80	150	[315]
Ames Flight Research Center	6,193	1,105	[1,245]
Dryden Research Center	334	300	[900]
Langley Research Center	5,124	5,925	[6,185]
Glenn Research Center	2,501	2,298	[2,035]
Goddard Space Flight Center	8,761	15,349	[12,690]
Jet Propulsion Laboratory	6,958	7,368	[7,705]
Headquarters	3,233	3,954	[3,830]
Total	43,000	47,396	[47,800]

**Beginning in FY 2002, SMA&E will be in the Human Space Flight Appropriation*
***Beginning in FY 2002, Advanced Concepts is funded in the SAT appropriation under Aerospace Technology*

PROGRAM GOALS

The Safety, Mission Assurance, Engineering, and Advanced Concepts (SMAEAC) area is an investment to enable the safety and success of all NASA programs. The SMAEAC budget supports the activities of the Office of Safety and Mission Assurance (OSMA), the Office of the Chief Engineer (OCE), and the former Office of the Chief Technologist (OCT). The OCT was merged with the Office of Aerospace Technology (OAT) in FY 2000, and OAT continues the former OCT's responsibilities. These Offices advise the Administrator, oversee NASA programs, develop Agency-wide policies and standards, and support the technology requirements of NASA flight programs. Each area is discussed separately.

SAFETY AND MISSION ASSURANCE

STRATEGY FOR ACHIEVING GOALS

The Safety and Mission Assurance (SMA) area assures that sound and robust SMA processes and tools are in place to enable safe and successful missions. This area establishes SMA strategies, policies, and standards, ensures that SMA disciplines are appropriately applied throughout the program life cycle. SMA also provides analysis, oversight, and independent assessment (IA) of programs, and flight and ground operations to ensure that suitable attention is placed on risk, missions are conducted safely, and there is a high probability of meeting Agency objectives. SMA funds research, development, pilot application, and evaluation of tools, techniques, and practices that advance NASA's SMA capabilities in areas such as facility and operational safety, risk management, human reliability, software assurance, and probabilistic risk analysis. Funding is also provided to develop SMA training courses.

ACCOMPLISHMENTS AND PLANS

In FY 2000, NASA achieved a lost time injury rate of 0.22 incidents per 200,000 workhours against a goal of 0.30. The FY 2001 goal is 0.28 lost time incidents per 200,000 workhours. Beginning in FY 2002, NASA uses the Federal Worker 2000 goal of remaining below 1.15 occupational illnesses or injuries per 100 workers.

The OSMA provided SMA support to, and independent review of, the International Space Station (ISS), Space Shuttle (4 missions), and science programs (including 6 expendable launch vehicle (ELV) payload launches) in FY 2000. Also in FY 2000, OSMA instituted an Independent Mission Assurance Review (IMAR) process for ELVs and payloads, similar to the preflight assurance review process for Space Station and Space Shuttle. Independent review of the ISS continues beyond FY 2002. Support and review will be provided to 7 Shuttle and 13 ELV and payload missions in FY 2001, and 7 Shuttle and 8 ELV and payload missions in FY 2002.

FY 2000 research, development, pilot application, and evaluation efforts for SMA tools, techniques and practices in disciplines such as operational and facility safety, risk management, quantitative risk analysis, software assurance, failure detection and prevention, parts assurance, and human reliability had the goal of enabling NASA safety and mission success. Revisions to the NASA Safety Manual; NASA Emergency Preparedness Plan Procedures and Guidelines; NASA Procedures and Guidelines for Mishap Reporting, Investigating, and Recordkeeping; and Government Safety and Mission Assurance Surveillance Functions for NASA Contracts were completed. In FY 2001 and 2002, OSMA will continue to identify, develop, update, and evaluate SMA policies, processes, tools, techniques and practices (including risk management, operational safety, quantitative risk analysis, software assurance, failure detection and prevention, and human reliability) to enable safety and mission success

OSMA completed 3 Center Process Verification Reviews in FY 2000, with more Centers to be reviewed in FY 2001 and 2002. Activities to maintain NASA's third-party ISO 9001 certification continue beyond FY 2002. Safety reviews for Mars missions that will carry nuclear materials were begun in 2001, and reviews of other missions that will carry nuclear materials are anticipated.

ENGINEERING

STRATEGY FOR ACHIEVING GOALS

The OCE oversees the conduct and improvement of NASA's engineering practice, manages the strategic crosscutting process to "Provide Aerospace Products and Capabilities" and independently evaluates ongoing programs, proposed concepts, and options for new programs. The OCE establishes policies, standards, guidance, and support for improving NASA engineering practices and technical capabilities, and manages the NASA Electronics Parts and Packaging Program, which supports evaluation and infusion of advanced electronic parts and packaging technology into NASA programs.

ACCOMPLISHMENTS AND PLANS

In FY 2000, the NASA Integrated Action Team (NIAT) – an activity led by the Office of the Chief Engineer (OCE) -- developed a set of 17 recommendations for improving the overall NASA engineering and program management process. In FY 2001, the Office of the Chief Engineer (OCE) will begin development of an agency-wide systems engineering process that will be piloted and integrated with an updated program management structure in FY 2002. In FY 2000, NASA established policies to improve the software engineering process and provide a continuing basis for raising capability levels. Implementing procedures and metrics will be developed in FY 2001 and piloted in FY 2002.

The NASA Chief Engineer's Office is also undertaking an activity to more quantitatively define and characterize risk on different missions and projects. By linking discussion of acceptable risk to other mission and project variables including cost, schedule and performance, NASA intends to avoid taking on unnecessary risks during the development of critical, operational missions and projects while also avoiding unnecessary and potentially costly risk reduction measures on more experimental missions and projects. NASA intends to fully implement consideration of risk in the definition and development of new missions and projects starting in the FY 2003 budget. Eventually, NASA intends to incorporate consideration of risk at the program level by looking across multiple low- and high-risk projects to examine whether a program has the correct overall risk profile.

Two Independent Assessments of programs in development and 17 Independent Annual Reviews (IARs) of ongoing programs were conducted in FY 2000. Eight Independent Assessments, including several science missions, the ISS Propulsion Module, and Shuttle upgrade projects are anticipated in FY 2001. Both Independent Assessments and IARs will continue at the same level in FY 2002. In FY 2000, an integrated cost estimating capability was established to improve estimating tools and to provide independent cost estimates for specific programs. In FY 2001 independent estimates are planned for three programs and improved models will be implemented; model development and independent estimates will continue in FY 2002. Systems Management Offices were established at each NASA Center to extend the independent evaluation function to the performing Center level.

In FY 2000, NASA completed identification of baseline voluntary consensus standards (VCS) for its NASA Preferred Technical Standards baseline and continues strong support for VCS development, implementing PL 104-113 and OMB A-119. On-line access to many of the adopted standards is available now and full access is planned for FY 2002. FY 2001 pilot initiatives will improve the use of standards include notifying using programs of standards updates and referencing lessons learned to relevant standards; these pilots will be extended NASA wide in FY 2002.

The NASA Electronic Parts and Packaging Program (NEPP) performs radiation testing, technology evaluation, and application readiness assessments of advanced electronics components and packaging technologies. In FY 2000, an integrated World Wide Web site was developed to make results of these evaluations available to users. Considerable emphasis is being placed on evaluation and infusing of "commercial off the shelf" technologies where they meet space reliability and performance requirements; guidance on use of new technologies was provided to several current programs in FY 2000. Continuing technology evaluations in FY 2001 will include advanced microprocessors, photonics, and extreme hi/low temperature behavior of components. In FY 2001, evaluations will include advanced sensor technologies, extremely low power devices, and high-density substrates.

ADVANCED CONCEPTS

STRATEGY FOR ACHIEVING GOALS

The Office of Aerospace Technology (OAT) is NASA's principal advocate for advanced technology. As such, the OAT advises the Administrator on technology matters and develops a NASA-wide investment strategy for innovative and advanced technology. The office leads the development of NASA-wide technology goals and objectives and oversees NASA technology policies, programs, processes, and capabilities. OAT also sponsors the NASA Institute for Advanced Concepts (NIAC), which addresses NASA strategic objectives requiring technology readiness ten to twenty years into the future. Funding for Advanced Concepts activities is recorded in the OAT budget beginning with FY 2002.

ACCOMPLISHMENTS AND PLANS

The NASA Institute for Advanced Concepts (NIAC) has completed the third full year of operation and all functions of the Institute have been fully implemented. During FY 2000 the NIAC awarded 6 Phase II contracts and 16 Phase I grants. Five additional Phase II awards have been made in FY 2001. Since the beginning of the contract, NIAC has awarded 46 Phase I grants and 16 Phase II contracts for a total value of $8.6 million. These awards to universities, small businesses, small disadvantaged businesses and large businesses were for the development of revolutionary advanced concepts that may have a significant impact on NASA's future aeronautics and space missions. For example, the *Mini-Magnetospheric Plasma Propulsion (M2P2)* System, which uses the solar wind for propulsion, is receiving additional funding from NASA's Marshall Space Flight Center (MSFC) and funds have been allocated for follow-on tests and analysis for its space propulsion application. Moreover, it has the potential to provide shielding from cosmic ray radiation. A concept for *Very large optics for the Study of Extrasolar Terrestrial Planet* has collaboration with NASA's Goddard Space Flight Center (GSFC) and MSFC and is directly connected to long term space science goals to image planets around other stars. A concept for a large *X-Ray Interferometry* has collaboration with GSFC and is directly connected with long term space science goals to study the structure and evolution of the universe. Other ongoing studies include using a constellation of steerable balloons for atmospheric studies and biologically inspired robotics. Also, during FY 2001 the next set of Phase I awards will be made and solicitations will be released for the next round of Phase I and Phase II awards.

MISSION SUPPORT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT | **SPACE COMMUNICATIONS SERVICES**

SUMMARY OF RESOURCES REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
	(Thousands of Dollars)			
Space Network	36,100			MS 2-4
NASA Integrated Services Network	53,600			MS 2-8
[Reimbursements [non-add]]	[43,000]			
Total	89,700			
Distribution of Program Amount by Installation				
Johnson Space Center	51,400			
Kennedy Space Center	14,000			
Marshall Space Flight Center	4,000			
Goddard Space Flight Center	17,400			
Jet Propulsion Laboratory	2,700			
Headquarters	200			
Total	89,700			

Note -- In FY 2001, funding for all these activities was requested under the Science, Aeronautics and Technology appropriation under the Space Operations program, and in FY 2002, funding for all these activities is consolidated in the Human Space Flight (HSF) appropriation account under the Space Operations program. See the crosswalk for Space Operations in the Special Issues section for comparison.

PROGRAM GOALS

The Space Communications goal is to provide high quality, reliable and cost-effective space operations services, which enable Enterprise mission execution. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The Space Operations Management Office (SOMO), located at the Johnson Space Center in Houston, manages the telecommunications, data processing, mission operation, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. In line with the National Space Policy, the SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participate with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for operational communications and associated information handling services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests.

The Space Communication Services segment of NASA's Space Communications program is composed of two major elements. The Space Network element provides communications support to human space flight missions and low-Earth orbital spacecraft compatible with the Tracking and Data Relay Satellite (TDRS) system and to expendable launch vehicles and research aircraft. The NASA Integrated Services Network (NISN) program element provides telecommunications interconnectivity among NASA flight support networks, project and mission control centers, data processing centers and facilities, contractor facilities, and investigator science facilities located throughout the nation and the world.

STRATEGY FOR ACHIEVING PROGRAM GOALS

The Space Operations program provides command, tracking, and telemetry data services between the ground facilities and flight mission vehicles. This includes all the interconnecting telecommunications services to link tracking and data acquisition network facilities, mission control facilities, data capture and processing facilities, industry and university research and laboratory facilities, and the investigating scientists. The program provides scheduling, network management and engineering, pre-flight test and verification, flight system maneuver planning and analysis. The program provides integrated solutions to operational communications and information management needs common to all NASA strategic enterprises.

The Space Operations program provides the necessary research and development to adapt emerging technologies to NASA communications and operational requirements. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the evaluation and coordination of data standards and communication frequencies to be used in the future.

Many science and exploration goals are achieved through inter-agency or international cooperation. Services from NASA's Space Operations assets are provided through collaborative agreements with other U.S. Government agencies, commercial space enterprises, academia, and international cooperative programs. Consistent with the National Space Policy, NASA procures commercially available goods and services to the fullest extent feasible, NASA develops selected technologies which leverage commercial investments and enable the use of existing and emerging commercial telecommunications services to meet NASA's Space Operations needs. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

The Consolidated Space Operations Contract (CSOC) was successfully implemented on January 1, 1999 under the direction of the Space Operations Management Office and Lockheed Martin Space Operations Company as the Prime Contractor. CSOC provides end-to-end space operations mission and data services to both NASA and non-NASA customers. CSOC is a $3.44B contract with a Basic Period of Performance from January 1999 through December 2003 and an option period though December 2008. CSOC is a Performance Based Cost Plus Award Fee (CPAF) contract. A total of nine contracts have been consolidated to date, and seven further contracts to be consolidated in FY 2001 and FY 2002. CSOC reflects a significant change in NASA philosophy as accountability and day to day direction for providing space operations services shifts from NASA to the CSOC contractor.

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BASIS OF FY 2002 FUNDING REQUIREMENT

SPACE NETWORK

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Space Network Services	4,400		
TDRS Replenishment Spacecraft	17,700		
TDRS Replenishment - Launch Services	14,000		
Total	36,100		

PROGRAM GOALS

The Space Network program goal is to provide reliable, cost-effective space-based tracking, command and data acquisition telecommunications services to the Human space Flight program, other low-Earth-orbital science missions including observatory-class flights, and selected sub-orbital flight missions. The Space Network program provides for the implementation, maintenance, and operation of the communications systems and facilities necessary to ensure and sustain the high-quality performance of NASA flight operations systems. Replenishment Tracking and Data Relay Satellites (TDRS) and the launch systems required to deploy them are also included in this program.

The Space Network participates in collaborative interagency and international programs, and independently provides communications services to other national and commercial endeavors on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

NASA's Space Network is comprised of a constellation of geosynchronous TDRS and associated dual ground terminals located in White Sands, New Mexico. The current TDRS constellation consists of four fully operational satellites in service (TDRS-4, 5, 6 & 7), and two partially functional spacecraft (TDRS-1 & 3), and one new satellite (TDRS-H launched in June 2000), which has not yet been accepted by NASA and continued to undergo operational assessment. TDRS-1, now in its seventeenth year, is still providing service to expendable vehicle launches and other peak loads in the eastern network node.

The Goddard Space Flight Center manages the Space Network program, including the TDRS Replenishment Spacecraft program, and the modification and/or system replacement of the ground facilities and equipment as necessary to sustain network operations for current and future missions. The Replenishment Spacecraft program providing three TDRS spacecraft under a fixed-price, commercial practices contract with Boeing (formerly Hughes Space and Communications Company). The first spacecraft, TDRS-H, was launched in June 2000. The program provides for spacecraft compatibility modifications to the New Mexico ground terminals. Lockheed Martin Corporation is the prime contractor for launch services for the TDRS Replenishment Spacecraft.

The Space Network provides communication services at data rates up to 300 megabits-per-second (MBPS) using its Ku-band single-access services, data rates of up to three MBPS using its S-band, single-access services, and a low-rate service of up to 150 kilobits-per-second (KBPS) through its multiple-access service. These services provide unparalleled, flexible high-data-rate communications capabilities for flight operations of low-Earth-orbital missions. Customer satellites are provided with command, tracking, and telemetry services via the TDRS spacecraft, which act as relays for commands from and science telemetry return to the ground terminals. The ground terminals are interconnected with flight control, data capture and processing facilities responsible for mission operations.

Communications services are provided to non-NASA customers on a reimbursable basis. A large share of the Space Network Services program that provides for the operations and maintenance of the ground terminal complex is funded with the receipts from reimbursable services.

Space Network services provides the primary communications for orbital operations of the Space Transportation System and its attached payloads. Services are also provided to automated Earth-orbital missions that have communications systems compatible with the TDRS, and can provide nearly continuous high-data-rate services. The Space Network initiated communications services for the International Space Station (ISS) beginning in FY 1999. Services will also be provided on an agreed-to basis to NASA's International partners. Agreements are in place with Japan, the European Space Agency, and Canada. Negotiations are continuing with the Russian Space Agency as a participant for potential cooperative endeavors in telecommunications.

In addition to the day-to-day operations of the Space Network satellites and ground terminals, the program provides for the replenishment of the satellite assets.

SCHEDULE AND OUTPUTS

	FY 2000		FY 2001		FY 2002
	Plan	Actual	Plan	Current	Plan
Number of hours of network service (thousands)	62,000	78,000			
Number of Space Shuttle Launches supported	6	4			

Refer to HSF 6-6 for comparison purposes to FY 2001 and FY 2002.

TDRS Replenishment Spacecraft

Pre-Environmental Review for TDRS-J Plan: February 2000 Actual: May 2000	Verification that the spacecraft is ready for system level environmental testing. Pre-environmental reviews were rephased due to a number of unit level problems on TDRS H, the uniqueness of the TDRS-H payload, and the first-time use of electronic ground test software on TDRS H.
Complete Integration and Test – TDRS-I Plan: March 2000 Revised: July 2001	Completion of spacecraft performance and environmental tests allows final assembly and re-testing to begin prior to shipment for launch.
Complete Integration and Test – TDRS-J Plan: May 2000 Revised: December 2001	Completion of spacecraft performance and environmental tests allows final assembly and re-testing to begin prior to shipment for launch.
Launch TDRS-H Plan: 3rd Qtr FY 2000 Actual: June 2000	Launch within five years of contract award will be performed, ensuring the continuity of TDRSS services to user space flight systems. Launch of TDRS-I and TDRS-J is now scheduled for 2002 and 2003.

<u>ACCOMPLISHMENTS AND PLANS</u>

The Space Network is required to operate 24 hours per day, 7 days per week, providing data relay services to many flight missions. In FY 2000, the missions supported included six Space Shuttle flights and their attached payloads, observatory-class spacecraft in low-Earth orbit such as Hubble Space Telescope (HST) and the Compton Gamma Ray Observatory (CGRO), as well as other compatible missions such as Ocean Topography Experiment, Extreme Ultraviolet Explorer (EUVE), Department of Defense customers, the Rossi X-ray Timing Explorer (RXTE), the Starlink research aircraft, Engineering Test Satellite (ETS-VII), Tropical Rainfall Measurement Mission(TRMM), Landsat-7 and the Long Duration Balloon program. The Space Network extended service (on a reimbursable basis) to the expendable launch vehicle community including agreements with US Air Force Titan and Lockheed Martin's commercial Atlas programs.

In FY 2000, the Space Network continued to provide services to the Space Shuttle Flights and their attached payloads as well as the construction phase of the International Space Station, LANDSAT-7, and the Earth Observing System Terra mission. Full-up support to the ISS will necessitate further increases in the level of communication services.

In FY 2000, the TDRS low power transceiver (LPT) prototype was delivered and the flight unit development was initiated. Completed LPT flight units are planned to be delivered in FY 2001.

Work began in FY 2000 on various components of the Demand Access System (DAS), including the Third Generation Beam Forming System (TGBFS). The TGBFS development activity was initiated to augment the TDRSS multiple-access (MA) capability and to permit customers to implement new operations concepts incorporating continuous return link communications. The DAS will expand existing Multiple Access (MA) return service capabilities by allowing customers to directly obtain services from the Space Network without scheduling through the Network Control Center (NCC). The TGBFS component is planned for completion in FY 2001. The DAS will be installed at White Sands, New Mexico, and is expected to be operational and available for customer use in FY 2002.

In FY 2000, the TDRS-H spacecraft was launched successfully. On-orbit checkout of the spacecraft was conducted in July-September 2000. The spacecraft is working well and meets most user service telecommunications performance requirements, except for a minor Multiple Access (MA) anomaly shortfall in performance. An investigation of the MA anomaly began in September 2000. TDRS-I and ¬J integration and test activities continued to progress and the TDRS-H MA anomaly is planned to be resolved in FY 2001.

BASIS OF FY 2002 FUNDING REQUIREMENT

NASA INTEGRATED SERVICES NETWORK (NISN)

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
NASA Integrated Services Network....................................	53,600		

PROGRAM GOALS

The NASA Integrated Services Network (NISN) goal is to provide high-quality, reliable, cost-effective telecommunications systems and services for mission control, science data handling, and program administration for NASA programs. The NISN program provides for the implementation, maintenance, and operation of the telecommunications services, control centers, switching systems, and other equipment necessary to provide an integrated approach to NASA communication requirements.

The NISN supports NASA's programs in collaborative interagency, international, and commercial enterprises. Many collaborative arrangements are performed on a reimbursable basis.

STRATEGY FOR ACHIEVING GOALS

NISN is a nationwide system of leased voice, video, and data services; leased wide-band terrestrial and satellite circuits; and control centers, switching centers, network equipment and other communications devices. International telecommunications links are also provided to NASA's Deep Space Network (DSN) sites in Australia and Spain; Spaceflight Tracking and Data Network (STDN) sites outside the Continental U.S.; and common telecommunications exchange points that provide interconnectivity to NASA international partners. Administrative, scientific, and mission control exchanges among NASA and its industrial and scientific partners are supported by NISN networks and systems. Support and participation by other U.S. agencies, universities, and research centers, and by other space-faring nations, are also facilitated, including the provision of secure circuits, systems, and facilities. Domestic Telecommunications circuits are primarily through commercial vendors; international circuits are leased under separate contractual arrangements. NISN maintains cooperative networking agreements for exchanging services with the European Space Agency (ESA), Canada, Japan, France, and Russia. The Computer Science Corporation and AlliedSignal Technical Services Corporation provide engineering and operations support for the NISN.

The NISN Project Office manages the NISN at the Marshall Space Flight Center in partnership with the Goddard Space Flight Center. NISN provides unique mission and mission support telecommunications services to all NASA Centers, supporting contractor locations, international partners, research institutes, and universities. NASA also provides telecommunications services to non-NASA customers on a reimbursable basis.

Command, telemetry, and voice systems communications are provided between spacecraft mission control facilities, tracking and data acquisition networks, launch sites, NASA data processing centers, and scientific investigators whose support is critical to mission control and command. NISN support NASA aeronautical test sites, as well as preflight verification of NASA spacecraft systems and their interconnectivity with NASA communications systems.

The NISN interconnects NASA installations and national and international aerospace contractors, laboratories, scientific investigators, educational institutions, and other Government installations in support of administrative, science data exchange, and other research and analysis activities. Specific mission support services provided by the NISN are voice and video teleconferencing, broadcast television, computer networking services, as well as data handling and transfer services including Internet connectivity.

NISN provides for the improvement, operation and maintenance of NASA network systems and facilities. Telecommunications network systems include digital voice, data and video switching equipment, audio and video conferencing and bridging systems, wide-band multiplexing equipment, and sophisticated network management, monitoring, and fault isolation systems. Equipment and facilities of NASA Select Television are also provided by the NISN.

Telecommunications services are rapidly developing and maturing. With the advancements of telecommunications technology and standards, NASA telecommunications services are now more readily available from commercial sources. NISN continually analyzes current telecommunications requirements to determine the feasibility of providing NASA telecommunications services through commercial sources. NISN also maintains a close relationship with the NASA Research and Education Network (NREN), NASA's research and development, to determine what information technologies are beneficial to support NASA's growing telecommunications needs. As technologies become standard and commercially available, NISN conducts study and cost analyses to determine the feasibility of purchasing these services for use by the NASA community.

SCHEDULE AND OUTPUTS

	FY 2000		FY 2001		FY 2002
	Plan	Actual	Plan	Current	Plan
Number of locations connected	420	347			

Refer to HSF 6-6 for comparison purposes to FY 2001 and FY 2002.

ACCOMPLISHMENTS AND PLANS

In FY 2000, NASA had major program developments in the Earth Observing System (EOS) and the International Space Station (ISS) Programs, resulting in corresponding increases in telecommunications services. For the EOS program, a 50 megabits per second (Mbps) data service was completed to support program level testing. Two 52 Mbps data services were also completed for the program, one to Norway and another to Alaska, to support the program's science data transfers.

Constrained travel budgets continue to increase the number of electronic conferences supported within NASA. Also, with the increased reliance on collaborative tools and conferencing, electronic conferences will continue to increase. As NASA enters the International Space Station (ISS) era with Principle Investigators located around the world, reliance on the networking services increases. However, increases in government-wide sponsored network services (example: very high speed Bandwidth Network Services (vBNS), Abilene, Next Generation Internet (NGI) network exchange points, Internet II), as well as industry-sponsored network services (regional Gigapops) have facilitated faster, more readily available and less expensive connectivity to many government, research, and university locations. NISN is actively involved in establishing relationships at these network connection points and in doing so will allow NISN to eliminate many dedicated services to principal researchers at locations across the US. With the establishment of a mission network based on asynchronous transfer mode (ATM) technology, many of the current dedicated point-to-point circuits will be eliminated as the network evolves to a mesh environment. This will result in decreased physical network connections, but increased virtual network connections in FY 2000-2002.

With the high level of involvement of the Russian Federation in the ISS program, NISN's telecommunications services to Russia were reevaluated and several redesigns of the services were completed to improve performance and reliability for the program. Data services were expanded to support launches at the Russian Baikonur facility, resulting in the ability to support critical communications transfers in the successful rendezvous and docking of the ISS Increment 1 crew.

In FY 2000, NISN continued to analyze commercial services for potential use in meeting NASA's expanding Mission Requirements. NASA will be adding services in support continued implementation of IFMP, CoSMO, ISS Phase II, National Oceanic and Atmospheric Administration (NOAA)-K, Earth Observation System, Advanced Composition Explorer (ACE), Advanced Earth Observing Satellite (ADEOS) and TRMM.

MI8SION SUPPORT

FY 2002 ESTIMATES

RESEARCH AND PROGRAM MANAGEMENT

PROGRAM GOALS

The primary goal of this budget segment is to acquire and maintain a civil service workforce which reflects the cultural diversity of the Nation and, along with the infrastructure, is sized and skilled consistent with accomplishing NASA's research, development, and operational missions with innovation, excellence, and efficiency. The budget proposed is constructed to achieve that goal. In accordance with the two-appropriation approach, the R&PM funds for FY 2002, displayed here for information purposes only, are allocated in the HSF and SAT accounts against the appropriate Enterprises. This allocation is based on the distribution of the direct full time equivalent (FTE) people associated with each Enterprise, along with a share of other than direct R&PM funds allocated using the relative percentages of direct FTE's by Enterprises. These funds will be identified within each Enterprise section under the title of "Institutional Support".

Beginning in FY 2002, there will no longer be a Mission Support account. Institutional costs will be budgeted within HSF and SAT (as discussed above) and Safety, mission assurance and engineering will be budgeted within the HSF account.

STRATEGY FOR ACHIEVING GOALS

This civil service workforce is the underpinning for the successful accomplishment of the Nation's civil aeronautics and space programs. These are the people who plan the programs; conduct and oversee the research; select and monitor the contractors; manage the various research, development, and test activities; and oversee all of NASA's operations. A key dimension of the reinvention of NASA has been the restructuring of the civil service workforce to deliver a space and aeronautics program that is balanced, relevant, and at the forefront of technology development.

During FY 2000, NASA recognized the need to strengthen the workforce in critical areas and renewed its focus on the restructure and revitalization of the NASA workforce. The halt in the influx of new college graduates as a result of years of downsizing, has skewed the age distribution of NASA's workforce. In FY 2002, NASA plans to develop an initiative to enhance Centers' recruitment capabilities, focusing on hiring freshouts. Additionally, beginning in FY 2000, the Agency embarked upon a strategy to accomplish work through a balance of permanent civil servants, time-limited civil service appointees, and individuals from the academic world who contribute through post-doctoral fellowships, grants programs, or on Intergovernmental Personnel Act assignments. The focus of this effort is to draw from a variety of sources to ensure the effective use of talent both within and outside the Agency. The use of non-permanent civil servants, where it makes sense, can be a means to infuse the NASA workforce with fresh ideas and allow the Agency to make changes quickly and efficiently, with minimal adverse impact on the core workforce. As part of our human capital investment strategy, we are working to attract and retain a world-class workforce with the necessary skills and competencies. We also encourage continual learning – including emphasis on technical training, leadership development, and career management. In recent years, NASA has placed a renewed emphasis on academic education and maintenance of leading edge and technical state of the art skills – on developing an environment conducive to life-long learning. In addition to funding more university level courses, the Agency has made a strong investment in ensuring NASA participation in conferences and symposia, where breakthrough research and ideas are being presented and shared, as well as providing training in safety, ISO 9001, information technology, and core functional areas.

In FY 2001, NASA will undertake a review of Critical Capabilities. U. S. academia and industry provide a rich R&D resource that NASA can tap to strengthen its mission capabilities. NASA will develop an integrated, long-term agency plan that ensures a national capability to support NASA's mission by: 1) identifying NASA's critical capabilities and, through the use of external reviews, determining which capabilities must be retained by NASA and which can be discounted or led outside the agency; 2) expanding collaboration with industry, universities and other agencies and outsourcing appropriate activities to fully leverage outside expertise; and 3) pursuing civil service reforms for capabilities that NASA must retain, to ensure recruitment and retention of top science, engineering and management talent at NASA.

Since FY 2000, the Agency has focused additional emphasis on "just in time" training and coaching opportunities provided to project leader and team members to improve project team competencies. In addition, NASA has updated its leadership model specifying the latest cutting edge skills and behaviors required for effective leadership. Additional resources have been provided for in the FY 2002 Agency budget to enable NASA to expand the delivery methods being utilized to develop the workforce. Specific emphasis will be placed on the development of e-learning alternatives that can be accessed at all locations and levels, and increasing the ability to expand participation levels across the Agency. In addition, new capabilities are being developed to facilitate learning within intact teams; delivering tailored content directly to a project team at the point in time specific training is needed. NASA is also engaged in a strategy to develop employees in the theories, methods and tools of learning organizations. Pilots are showing that these skills enhance motivation, communication, and understanding of complex systems.

Research and Program Management Budget

The Research and Program Management (R&PM) program provides the salaries, other personnel and related costs, travel and the necessary support for all of NASA's administrative functions and other basic services in support of research and development activities at NASA installations. The salaries, benefits, and supporting costs of this workforce comprise approximately 78% of the requested funding. Administrative and other support is 20% of the requests. The remaining 2% of the request is required to fund travel necessary to manage NASA and its programs.

The FY 2002 budget estimate of $2,460.5 million for Research and Program Management represents an increase of $185.1 million from the FY 2001 budget plan of $2,275.4 million. Of this total increase, Personnel and related costs increase by $99.9 million from FY 2001 to FY 2002. These increases fully fund the civil service workforce, the full year cost of the 2001 payraise, the payraise projected to be effective in January 2002, increased costs of health care, normal salary growth and an increase in training. Travel represents a slight increase of $1.5 million over the FY 2001 budget plan due to increased requirements for Space Station. Research Operations Support increases by $83.7 million from the FY 2001 budget plan of $426.0 due to transfers out of Program into ROS for

Institutional funding items, an augmentation to the Headquarters Operations budget for the CIO Initiatives, Implementation of a Counter Intelligence Program, Scientific and Technical Upgrades, projected rent increases and an increase for IFMS. The IFMS increase reflects the continued high level of activity planned for the implementation of the Integrated Financial Management System (IFMS). Award of this contract was made late in Fiscal Year 2000 and will encompass fourteen modules. Core Financial, Procurement Management, Time and Attendance, Budget Formulation, Core Human Resources, Position Classification, Resume Management, Logistics, Travel Management, Environmental, Aircraft Management, Facilities, Payroll and Technical Refreshments. The overall implementation approach provides for a single contractor to work across all ten NASA centers to implement a single, integrated system. Centers will support the implementation contractor by providing guidance, data, and access to current systems.

FTE levels that were included in Program Operations (which were mostly Center Management and Operations) in prior R&PM FTE allocations, are now included in Institutional Support in the Enterprise summaries for each Center.

In summary, the FY 2002 proposed budget of $2,460.5 million will provide for 18,237 full-time permanent civil service workyears, and 18,792 FTE civil service workyears (not including the NASA Office of Inspector General) to support the activities at nine NASA Installations and Headquarters. NASA plans to control personnel levels through full time permanent (FTP) civil servant workyears while continuing to track full-time equivalent workyears, as done in the past. This will allow NASA more flexibility in the use of non-permanent positions for short-term technical needs as well as co-op and intern programs.

The following describes, in detail, the cost elements within this program.

I. Personnel and Related Costs

A. Compensation and Benefits

1. Compensation

a. Permanent Positions: This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce and is the largest portion of this functional category.

b. Other Than Full-Time Permanent Positions: This category includes the salaries of NASA's non-permanent workforce. Programs such as Presidential Management Interns, students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support are covered in this category.

c. Reimbursable Detailees: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of persons detailed to NASA.

d. Overtime and Other Compensation: Overtime, holiday, post and night differential, and hazardous duty pay are included in this category. Also included are incentive awards for outstanding achievement and superior performance.

2. Benefits: In addition to compensation, NASA, as authorized and required by law, makes the employer's contribution to personnel benefits. These benefits include contributions to the Civil Service Retirement Fund, the Federal Employees Retirement System, employees' life and health insurance, payments to the Medicare fund for permanent employees, and social security contributions. Payments to the civil service retirement fund for re-employed annuitants and severance pay to former employees involuntarily separated through no fault of their own are also included.

B. Supporting Costs

1. Transfer of Personnel: Provided under this category are relocation costs required by law, such as the expenses of selling and buying a home, subsistence expenses, and the movement and storage of household goods.

2. Investigative/Other Services: The Office of Personnel Management is reimbursed for activities such as security investigations of new hires and revalidation of sensitive position clearances. In addition, this category pays for, recruitment advertising, and materials, personnel/workforce studies and Federal wage system surveys.
3. Personnel Training: Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs is for courses offered by other Government agencies, and the remainder is for training through nongovernment sources.

II. Travel

A. Program Travel: The largest part of travel is for direction, coordination, and management of program activities including international programs and activities. The complexity of the programs and the geographical distribution of NASA Installations and contractors necessitate this category of travel. As projects reach the flight stage, support is required for prelaunch activities including overseas travel to launch and tracking sites. The amount of travel required for flight projects is significant as it is directly related to the number of systems and subsystems, the number of design reviews, and the number and complexity of the launches and associated ground operations.

B. Scientific and Technical Development Travel: Travel to scientific and technical meetings and seminars permits employees engaged in research and development to participate in both Government sponsored and nongovernment sponsored activities. This participation allows personnel to benefit from exposure to technological advances, which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates and provides for the dissemination of technical results to the United States community.

C. Management and Operations Travel: Management and operations travel provides for the direction and coordination of general management matters and travel by officials to review the status of programs. It also includes travel by functional managers in such areas as personnel, financial management, and procurement. This category also includes the cost of travel of unpaid members of research advisory committees; and initial duty station, permanent change of assignment, and related travel expenses.

III. Research Operations Support

A. Facilities Services: Facilities Services provides basic security, fire protection, and other custodial services. It also provides maintenance of roads and grounds and of all administrative buildings and facilities. Finally, it provides rental of administrative buildings and all utility costs of administrative buildings.

B. Technical Services: Technical Services provides the Administrative Automatic Data Processing capability that supports Accounting, Payroll, Budgeting, Procurement, and Personnel as well as all the other Administrative functions. It also funds the Graphics and Photographic support to these functions. Finally, it funds the Installation-wide safety and public information programs.

C. Management and Operations: Management and Operations funds the telephone, mail, and logistics systems, the administrative equipment and supplies, and the transportation system including the general purpose motor pools and the program support aircraft. It also funds the basic medical and environmental health programs. Finally, it funds printing and reproduction and all other support, such as small contract and purchases for the Center Directors staff and the Administrative functions.

SUMMARY OF BUDGET PLAN BY FUNCTION
(Thousands of Dollars)

	FY 1999 OP PLAN REVISED	FY 2000 OP PLAN REVISED	FY 2001 PRES BUDGET
PERSONNEL AND RELATED COSTS	$1,675,969	$1,796,340	($1,896,200)
TRAVEL	$49,975	$53,083	($54,600)
RESEARCH OPERATIONS SUPPORT	$473,800	$425,952	($509,700)
TOTAL PROGRAM PLAN	**$2,199,744**	**$2,275,375**	**($2,460,500)**

DETAIL OF BUDGET PLAN BY FUNCTION
(Thousands of Dollars)

	FY 2000	FY 2001	FY 2002
I. Personnel and related costs	**$1,675,969**	**$1,796,340**	**($1,896,200)**
A. Compensation and benefits	$1,615,175	$1,735,528	($1,820,266)
1. Compensation	$1,325,809	$1,434,025	($1,501,372)
2. Benefits	$289,366	$301,503	($318,894)
B. Supporting costs	$60,794	$60,812	($75,934)
1. Transfer of personnel	$10,201	$8,637	($7,995)
2. Investigative services	$2,710	$1,888	($2,817)
3. Personnel training	$47,883	$50,287	($65,122)
II. Travel	**$49,975**	**$53,083**	**($54,600)**
A. Program travel	$30,630	$32,560	($33,470)
B. Scientific and technical development travel	$6,910	$7,340	($7,545)
C. Management and operations travel	$12,435	$13,183	($13,585)
III. Research operations support	**$473,800**	**$425,952**	**($509,700)**
A. Facilities services	$132,100	$126,252	($135,700)
B. Technical services	$203,800	$154,700	($214,439)
C. Management and operations	$137,900	$145,000	($159,561)
Total	**$2,199,744**	**$2,275,375**	**($2,460,500)**

DISTRIBUTION OF BUDGET PLAN BY FUNCTION BY INSTALLATION
(Thousands of Dollars)

FUNCTION	TOTAL NASA	JSC	KSC	MSFC	SSC	GSFC	ARC	DFRC	LARC	GRC	JPL	HQS
PERSONNEL AND RELATED COSTS												
FY 2000	1,675,969	291,345	154,770	235,495	22,325	289,375	145,506	53,361	198,072	170,425		115,295
FY 2001	1,796,340	312,134	166,503	250,888	24,165	307,890	152,690	57,448	211,069	180,041		133,512
FY 2002	1,896,200	325,695	176,599	262,591	25,286	318,373	162,344	58,153	219,483	183,120		164,556
TRAVEL												
FY 2000	49,975	9,056	4,316	7,259	745	7,747	3,967	1,579	5,107	3,848		6,351
FY 2001	53,083	8,958	5,519	6,330	758	7,473	3,701	1,472	4,994	3,977		9,901
FY 2002	54,600	8,750	5,400	6,300	700	7,479	3,700	1,400	4,900	3,900		12,071
RESEARCH OPERATIONS SUPPORT												
FY 2000	473,800	39,853	91,673	69,467	21,300	77,828	32,712	6,548	28,006	25,779	399	80,235
FY 2001	425,952	44,928	75,649	69,412	18,699	61,124	35,651	4,770	21,177	26,206	270	68,066
FY 2002	509,700	46,441	77,844	62,119	22,330	61,230	33,967	4,900	29,746	28,101	300	142,722
TOTAL												
FY 2000	2,199,744	340,254	250,759	312,221	44,370	374,950	182,185	61,488	231,185	200,052	399	201,881
FY 2001	2,275,375	366,020	247,671	326,630	43,622	376,487	192,042	63,690	237,240	210,224	270	211,479
FY 2002	2,460,500	380,886	259,843	331,010	48,316	387,082	200,011	64,453	254,129	215,121	300	319,349

SUMMARY OF BUDGET PLAN BY INSTALLATION
(Thousands of Dollars)

	FY 2000	FY 2001	FY 2002
JOHNSON SPACE CENTER	$340,254	$366,020	$380,886
KENNEDY SPACE CENTER	$250,759	$247,671	$259,843
MARSHALL SPACE FLIGHT CENTER	$312,221	$326,630	$331,010
STENNIS SPACE CENTER	$44,370	$43,622	$48,316
GODDARD SPACE FLIGHT CENTER	$374,950	$376,487	$387,082
AMES RESEARCH CENTER	$182,185	$192,042	$200,011
DRYDEN FLIGHT RESEARCH CENTER	$61,488	$63,690	$64,453
LANGLEY RESEARCH CENTER	$231,185	$237,240	$254,129
GLENN RESEARCH CENTER	$200,052	$210,224	$215,121
HEADQUARTERS	$201,881	$211,479	$319,349
JET PROPULSION LABORATORY	$399	$270	$300
AGENCY TOTAL	**$2,199,744**	**$2,275,375**	**$2,460,500**

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY INSTALLATION

	FY 2000	FY 2001	FY 2002
Johnson Space Center	2,929	3,036	3,021
Kennedy Space Center	1,740	1,825	1,835
Marshall Space Flight Center	2,576	2,758	2,785
Stennis Space Center	272	280	300
Goddard Space Flight Center	3,288	3,311	3,316
Ames Research Center	1,451	1,464	1,486
Dryden Flight Research Center	617	635	609
Langley Research Center	2,360	2,396	2,364
Glenn Research Center	1,970	1,973	1,922
Headquarters	980	1,063	1,154
Total, full-time equivalents	**18,183**	**18,741**	**18,792**

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**7,416**	**7,779**	**8,092**
International Space Station	2,340	2,396	2,573
Space Operations (SOMO)	353	352	356
Space Flight Operations (Space Shuttle)	1,783	1,968	1,998
Payload & ELV Support	280	306	319
Investment - HEDS	733	737	747
HEDS Mission Support	1,927	1,990	2,069
HEDS Reimbursable Activities	0	30	30
SPACE SCIENCE	**2,489**	**2,221**	**2,314**
Major Development Programs	328	302	257
Payloads Program	38	31	30
Explorer Program	180	180	185
Mars Surveyor Program	64	89	97
Discovery Program	17	18	22
Operating Missions	10	5	3
Research and Technology	1,069	870	914
Space Science Mission Support	783	726	803
BIOLOGICAL & PHYSICAL RESEARCH	**485**	**489**	**484**
Biological & Physical Research	382	372	362
B&PR Mission Support	103	117	122
EARTH SCIENCE	**1,976**	**1,816**	**1,733**
Earth Observing System Program	462	424	409
Earth Probes Program	152	99	76
Operating Missions	30	33	28
Research and Technology	597	546	556
Earth Science Mission Support	640	633	585
ES Reimbursable Activities	95	81	79

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM (continued)

	FY 2000	FY 2001	FY 2002
AERO-SPACE TECHNOLOGY	**5,713**	**6,305**	**6,033**
Aero-space Focused Programs	1,375	1,756	1,500
High Speed Research Program	1	0	0
Advanced Subsonics Tech Program	2	0	0
Aero-Space Base	2,582	2,337	2,294
Commercial Technology Program	205	219	223
Code R New Initiative	138	8	8
Space Base Program	0	313	292
Investment - AST	10	9	9
Aero-Space Technology Mission Support	1,400	1,663	1,707
SAFETY AND MISSION ASSURANCE	**66**	**87**	**87**
Safety and Mission Assurance	66	87	87
ACADEMIC PROGRAMS	**38**	**45**	**50**
Total full-time equivalents (FTEs)	**18,183**	**18,741**	**18,792**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2002 ESTIMATES

LYNDON B. JOHNSON SPACE CENTER

ROLES AND MISSIONS

SPACE STATION - The Johnson Space Center (JSC) has lead center management responsibility for the International Space Station (ISS) program. In addition, specific JSC technical responsibilities include development of a set of facilities and systems to conduct the operations of the Space Station including on-orbit control of the Space Station.

The Center also provides institutional personnel as well as engineering and testbed support to the Space Station program. This includes test capabilities, the provision of Government Furnished Equipment, and engineering analysis support for the work of the prime contractor, its major subcontractors, and NASA system engineering and integration efforts.

SPACE SHUTTLE - JSC has lead center management responsibility for the Space Shuttle. In addition, JSC will provide development, integration, and operations support for the Mission Control Center (MCC), the Shuttle Mission Simulator (SMS), and other ground facilities needed for Space Shuttle Operations. JSC will provide Space Shuttle operational flight program management including system integration, crew equipment modification and processing, crew training, flight mission planning and operations, and procurement of Orbiter hardware.

PAYLOAD AND UTILIZATION OPERATIONS - JSC will also conduct concept studies and development on flight systems and options for human transportation. JSC provides support to the engineering and technical base, payload operations and support equipment, and technology program support.

SPACE SCIENCE – JSC is responsible for leadership in the field of astromaterials and operates NASA's astromaterial curatorial facility for extraterrestrial sample materials. The Center supports the Agency's Space Science goals through research, information dissemination, and interaction with the scientific community. This research includes planetary science, astrobiology, space debris, and sample material handling. The primary focus is on the composition, structures, and evolutionary histories of astromaterials to further our understanding of the solar system and aid in the planning for future missions.

BIOLOGICAL AND PHYSICAL RESEARCH - JSC is the Lead Center for the following programs/functions: Biomedical Research and Countermeasures; Advanced Human Support Technologies; and Space Medicine. It also has a supporting role in the Microgravity Research program in biotechnology. As part of these activities, JSC will develop, coordinate and evaluate human physiological changes associated with the space flight environment and develop effective countermeasures to assure crew health and optimal performance during all phases of flight. Protection of flight crewmembers from the hazards of space radiation is one of NASA's highest priorities. A strategic plan for Space Radiation Health has been developed to acquire the knowledge necessary to predict radiation risks in space and to develop countermeasures that include advances at the cutting edge of modern technology. JSC will also define and develop on-board health care systems and environmental monitoring systems; crew medical training; ground-based medical support of missions; develop a longitudinal crew health data base; and develop medical and psychological crew selection criteria. The JSC has established a Center for the support of biotechnology applications in Microgravity in order to study growth factors, medical chemo/immunotherapeutic, and human tissue transplantation. The Center will integrate life science flight experiments for Spacehab and the ISS; operate integrated payload systems; and train mission specialists in the science aspects of their missions.

MISSION/SPACE COMMUNICATION SERVICES - The Space Operations Management Office (SOMO), manages the telecommunication, data processing, mission operation, and mission planning services needed to ensure that the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. The SOMO also provides the administration and management of the Consolidated Space Operations Contract (CSOC).

CENTER MANAGEMENT AND OPERATIONS - Provides management, administrative, and financial oversight of NASA programmatic elements under JSC cognizance. In addition, the Center provides for the operation and maintenance of the institutional facilities, systems, and equipment. These functions are distributed under Institutional Support across the different Enterprises. JSC also coordinates the development of agency-wide foreign travel policy and processes all foreign travel.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
JOHNSON SPACE CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**2,748**	**2,815**	**2,800**
International Space Station	1,007	1,049	1,037
Space Operations (SOMO)	40	41	41
Space Flight Operations (Space Shuttle)	789	865	850
Investment - HEDS	324	324	335
HEDS Mission Support	588	536	537
SPACE SCIENCE	**45**	**60**	**60**
Mars Surveyor Program	8	2	0
Discovery Program	2	2	2
Operating Missions	3	3	3
Research and Technology	31	42	44
Space Science Mission Support	1	11	11
BIOLOGICAL & PHYSICAL RESEARCH	**110**	**130**	**130**
Biological & Physical Research	106	108	108
B&PR Mission Support	4	22	22
AERO-SPACE TECHNOLOGY	**20**	**23**	**23**
Aero-space Focused Programs	2	0	0
Aero-Space Base	2	2	2
Commercial Technology Program	15	16	16
Aero-Space Technology Mission Support	1	5	5
SAFETY AND MISSION ASSURANCE	**6**	**8**	**8**
Safety and Mission Assurance	6	8	8
Total full-time equivalents (FTEs)	**2,929**	**3,306**	**3,021**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2002 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

ROLES AND MISSIONS

SPACE STATION - The Kennedy Space Center (KSC) is a supporting center for the Space Station Program. The KSC has developed a set of facilities, systems, and capabilities to conduct the operations of the Space Station. KSC develops launch site operations capabilities for conducting pre-launch and post-landing ground operations including integrated testing, interface verification, servicing, launch activities, and experiment-to rack physical integration. The KSC provides launch site logistics support, re-supply, and customer utilization. The KSC serves as the primary agent for management and integration of ground processes for all U.S. launched International Space Station (ISS) elements from manufacture and assembly through verification and launch. The KSC develops and maintains ISS flight systems expertise to support the ISS on-orbit mission and retains technical and operational experience within NASA and KSC for ground processing and verification of space flight hardware for follow-on programs.

SPACE SHUTTLE - KSC will provide the technical expertise and services for Space Shuttle processing, launch and landing operations, and program integrated logistics. This includes Shuttle element processing; SRM/SRB element buildup; Shuttle element and payload integration; and operation and maintenance of the Shuttle processing, launch, and landing facilities, systems, associated technical infrastructure, and Ground Support Equipment (GSE).

PAYLOAD CARRIERS AND SUPPORT - KSC is the Lead Center for the Payload Carriers and Support Program. KSC provides technical expertise, facilities and capabilities to perform payload buildup, test and checkout, integration and servicing of multiple payloads; development, operation, logistics and maintenance of GSE; transportation of payloads and supporting equipment to the Space Shuttle; and integration and installation of the payloads into the Space Shuttle. The KSC develops, activates, operates, and maintains the Payload Carrier facility system, GSE, and processes to enable efficient launch site processing of carriers and payloads.

EXPENDABLE LAUNCH VEHICLES - KSC will provide government insight/oversight of all launch vehicle and payload processing and checkout activities for all NASA contracted expendable launch vehicle and upper stage launch services both at KSC and the Vandenburg Air Force Base.

CENTER MANAGEMENT AND OPERATIONS - KSC will provide administrative and financial services in support of Center management and will provide for the operation and maintenance of the institutional facilities, systems, laboratories, test beds, associated technical infrastructure, and equipment. These functions are distributed under Institutional Support across the different Enterprises. KSC’s Base Operations and Support Contract was re-competed recently as a joint NASA/U.S. Air Force contract that was awarded to Space Gateway Support. The jointly managed NASA/Air Force contract provides base operation services for KSC, 45th Space Wing and the Cape Canaveral Air Force Station including building and structure maintenance, roads and grounds, medical, security, fire protection, and a wide variety of other mission support. Kennedy also coordinates the development of the agency relocation policy and manages the NASA relocation contract which facilitates the sale and purchase of homes for employees that are transferred between centers. They are also the Lead Center for Occupational Health, and for NASA's Drug Free Workplace Program.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
JOHN F. KENNEDY SPACE CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**1,635**	**1,718**	**1,723**
International Space Station	309	317	317
Space Flight Operations (Space Shuttle)	640	669	688
Payload & ELV Support	202	226	226
Investment - HEDS	91	89	90
HEDS Mission Support	393	407	392
HEDS Reimbursable Activities	0	10	10
SPACE SCIENCE	**8**	**9**	**13**
Space Science Mission Support	8	9	13
BIOLOGICAL & PHYSICAL RESEARCH	**12**	**17**	**18**
Biological & Physical Research	12	17	18
AERO-SPACE TECHNOLOGY	**74**	**70**	**70**
Aero-space Focused Programs	24	24	24
Commercial Technology Program	20	20	20
Aero-Space Technology Mission Support	30	26	26
SAFETY AND MISSION ASSURANCE	**11**	**11**	**11**
Safety and Mission Assurance	11	11	11
Total full-time equivalents (FTEs)	**1,740**	**1,825**	**1,835**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2002 ESTIMATES

GEORGE C. MARSHALL SPACE FLIGHT CENTER

ROLES AND MISSIONS

SPACE PROPULSION - As NASA's designated Center of Excellence for Space Propulsion, the Marshall Space Flight Center (MSFC) leads the Agency's efforts in development, implementation and advocacy of advanced Earth-to-orbit and in-space propulsion systems and technologies. MSFC has responsibility for research, technology maturation, design, development, and integration of space transportation and propulsion systems. This includes both reusable space transportation systems for Earth-to-orbit applications, as well as vehicles for orbital transfer and deep space transportation.

SPACE TRANSPORTATION – MSFC has responsibility for research, technology maturation, design, development, and integration of space transportation and propulsion systems. This includes both reusable space transportation systems for Earth-to-orbit applications, as well as vehicles for orbital transfer and deep space transportation. MSFC is the lead Center for the Space Launch Initiative, with the goal—by the 2005 time frame—of enabling full-scale development of commercially competitive, privately owned and operated, Earth –to-orbit Reusable Launch Vehicles (RLVs). The objective will be to dramatically improve safety while significantly reducing the cost of launch services.

SPACE SHUTTLE ELEMENTS - MSFC's Space Shuttle projects manage safe, continuous, robust, and cost-effective operations for the Space Shuttle propulsion elements: External Tank, Solid Rocket Booster, Reusable Solid Rocket Motor, and Space Shuttle Main Engine. MSFC continues to streamline operations and aggressively develop and implement significant upgrades to enhance safety, meet the manifest, improve mission supportability, and improve the system to sustain the Space Shuttle for its lifetime.

INTERNATIONAL SPACE STATION (ISS) - MSFC supports the ISS program through task agreements with the ISS Program Office at the Johnson Space Center (JSC). MSFC plays a vital role in building, operating, and utilizing the ISS for NASA through the performance of these tasks. Specifically, MSFC provides management oversight of Nodes 2 and 3, which will be provided by the Italian Space Agency and their contractor, Alenia. The purpose of these sections of the United States On-Orbit Segment is to act as a building block to connect utilities, and provide a pressurized passageway between berthed elements. Commands and data will be distributed/transferred, as well as audio, video, electrical power, thermal energy, atmosphere, and water. MSFC has also provided management oversight of the Interim Control Module being built by the Naval Research Laboratory, and the United States Propulsion System (USPS). The USPS incorporates a propulsion module and a Node 4 docking module element. MSFC is responsible for the development of the regenerative life support systems for the ISS crew and the research animals. MSFC's Testing, Manufacturing and Support Team will provide technical expertise to ISS design and development teams. MSFC is also responsible for the management, integration and execution of payload operations and utilization activities on board the ISS.

SPACE SCIENCE RESEARCH - MSFC is responsible for managing the overall design, development, integration, test, and flight operations of the Gravity Probe–B (GP–B) flight experiment. The GP–B objective is to test two extraordinary predictions of Einstein's Theory of General Relativity, namely "geodetic precession" and "frame dragging," both of which describe distortions in the space-time continuum. MSFC also manages the Solar B and the GLAST Burst Monitor, and conducts fundamental research in six disciplines—cosmic-ray physics, gamma-ray astronomy, x-ray astronomy, solar physics, space plasma physics and astrobiology. MSFC manages the operation of the MSFC developed Chandra X-ray Observatory through the Operations Control Center and the Chandra X-ray Center at the Smithsonian Astrophysical Observatory in Cambridge, MA.

SPACE OPTICS MANUFACTURING TECHNOLOGY - MSFC leads the Agency in the development of lightweight, large-aperture Space Optics Manufacturing Technology for use in achieving the mission goals of NASA's strategic enterprises.

EARTH SCIENCE - Through the Global Hydrology and Climate Center (GHCC), a joint venture with academia, MSFC engages in research, education, and the development of Earth science applications. The GHCC focuses on using advanced technology to observe and understand the global climate system and applies this knowledge to agriculture, urban planning, water resource management, and operational meteorology.

OFFICE OF BIOLOGICAL AND PHYSICAL RESEARCH - MSFC is responsible for implementing the Agency's microgravity initiatives through the Microgravity Research and Space Product Development programs. MSFC's efforts enable scientific and commercial researchers the unique opportunity to use the low gravity environment of space as a catalyst to generate new knowledge, products, and services that improve the quality of life on earth. MSFC is also responsible for implementing the Materials Science and Biotechnology Science disciplines and the Glovebox Program within the Microgravity Research Program.

NATIONAL SPACE SCIENCE AND TECHNOLOGY CENTER - The National Space Science and Technology Center (NSSTC), headquartered in Huntsville, Alabama, is a research and education institution that provides an environment for selected key scientific disciplines. It consists of researchers and resources from government, academia and industry collaborating in an environment that enables cutting edge basic and applied research and fosters education of the next generation of scientists and engineers. The NSSTC is a partnership between NASA and the State of Alabama through the Alabama Space Science & Technology Alliance (SSTA) to perform research meeting the nation's needs.

AGENCY SUPPORT ACTIVITIES - A broad range of personnel, facilities, and operational support services are required to support Agency functions assigned to MSFC. MSFC has responsibility for the following Agency support activities: Communications Architecture and Providing Agency WAN Services; NASA Automated Data Processing Consolidation Center; NASA Digital Television Transition; NASA Integrated Service Network; NASA Preferred Technical Standards Program; NASA Acquisition Internet Service; NASA Operational Environment Team; National Center for Advanced Manufacturing; NASA Engineering Infrastructure; Earned-Value Management; Defense Contract Administrative Service Financial Management Support; Integrated Financial Management Program Core Financial Project; and the Integrated Financial Management Program Integration Project. The IFM Core Financial Project provides the management and technical leadership for the Agency-wide implementation of a standard financial system and processes necessary to support NASA's financial management activities. The first of several potential IFM projects, Core Financial will provide the backbone of the IFM Program and consists of the following components: standard general ledger, accounts receivable, accounts payable, budget execution, purchasing, fixed assets, project accounting, and cost allocation. MSFC manages the project and will serve as the pilot center for implementation of the core financial software.

CENTER MANAGEMENT AND OPERATIONS – MSFC provides administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems and equipment. These functions are distributed under Institutional Support across the different Enterprises.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
GEORGE C. MARSHALL SPACE FLIGHT CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	1,506	1,655	1,700
International Space Station	689	696	678
Space Operations (SOMO)	10	10	10
Space Flight Operations (Space Shuttle)	320	401	426
Payload & ELV Support	8	22	32
Investment - HEDS	264	268	267
HEDS Mission Support	215	258	287
SPACE SCIENCE	220	199	183
Major Development Programs	10	23	19
Payload Program	10	11	11
Operating Missions	2	2	2
Research and Technology	165	130	122
Space Science Mission Support	33	33	29
BIOLOGICAL & PHYSICAL RESEARCH	103	110	110
Biological & Physical Research	89	92	90
Biological & Physical Research Mission Support	14	18	20
EARTH SCIENCE	57	51	50
Earth Observing System Program	3	3	3
Research and Technology	39	37	37
Earth Science Mission Support	6	9	8
ES Reimbursable Activities	9	2	2
AERO-SPACE TECHNOLOGY	666	720	719
Aero-space Focused Programs	279	416	370
Aero-space Base	253	133	179
Commercial Technology Program	33	27	27
Code R New Initiatives	8	8	8
Space Base Program	0	16	14
Aero-Space Technology Mission Support	93	120	121

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
GEORGE C. MARSHALL SPACE FLIGHT CENTER (continued)

	FY 2000	FY 2001	FY 2002
SAFETY AND MISSION ASSURANCE	24	23	23
Safety and Mission Assurance	13	12	12
ACADEMIC PROGRAMS	11	11	11
Total full-time equivalents (FTEs)	2,576	2,758	2,785

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

JOHN C. STENNIS SPACE CENTER

ROLES AND MISSIONS

HUMAN SPACE FLIGHT - As the Lead Center for Propulsion Testing, SSC will operate, maintain, and manage a propulsion test capability that includes test facilities at JSC/WSTF, MSFC and GRC/Plum Brook and related systems for development, certification, and acceptance of rocket propulsion systems and components. The Center will provide, maintain, and manage the facilities and the related capabilities required for the continued development and acceptance testing of the Space Shuttle Main Engines. SSC will also maintain and support the Center's technical core laboratory and operations to enable SSC to conduct advanced propulsion test technology research and development for government and commercial propulsion programs.

EARTH SCIENCE - Through the Commercial Remote Sensing Program, SSC will enhance U.S. economic competitiveness via commercial partnership programs that apply remote sensing technologies in business applications and reduce new product development costs. As part of the Applied Research and Data Analysis program, SSC will conduct fundamental and applied research which increases our understanding of environmental systems sciences, with emphasis on coastal research of both land and oceans.

AERONAUTICAL RESEARCH AND TECHNOLOGY - Through the Technology Transfer and Small Business Innovative Research programs, SSC will broaden and accelerate the development of spin-off technologies derived from national investments in aerospace research. SSC will also support the development of new and innovative propulsion technologies through the Advanced Space Transportation Program that supports the Agency goal of reducing the cost of access to space.

CENTER MANAGEMENT AND OPERATIONS – SSC provides administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems, and equipment. The Center will provide, operate, maintain, and manage the institutional base and laboratories required to support NASA programs, Commercial programs, and other Federal and State agencies and organizations resident at the SSC. These functions are distributed under Institutional Support across the different Enterprises.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
STENNIS SPACE CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**136**	**142**	**161**
International Space Station	21	21	22
Investment - HEDS	54	55	55
HEDS Mission Support	61	46	64
HEDS Reimbursable Activities	0	20	20
EARTH SCIENCE	**52**	**48**	**47**
Earth Observing System Program	0	0	1
Research and Technology	28	28	27
Earth Science Mission Support	24	20	19
AERO-SPACE TECHNOLOGY	**72**	**71**	**68**
Aero-space Focused Programs	19	24	21
Aero-space Base	17	14	16
Commercial Technology Program	4	4	4
Aero-Space Technology Mission Support	32	29	27
SAFETY AND MISSION ASSURANCE	**1**	**1**	**1**
Safety and Mission Assurance	1	1	1
ACADEMIC PROGRAMS	**11**	**18**	**23**
Total full-time equivalents (FTEs)	**272**	**280**	**300**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2001 ESTIMATES

GODDARD SPACE FLIGHT CENTER

ROLES AND MISSIONS

SPACE SHUTTLE/PAYLOAD AND UTILIZATION OPERATIONS - GSFC manages flights of the Hitchhiker, a reusable carrier system which provides increased flight opportunities with reduced leadtime while maximizing Space Shuttle load factors and minimizing spaceflight costs. GSFC also manages and coordinates the Agency's Get Away Special (GAS) program.

SPACE SCIENCE - GSFC manages physics and astronomy activities in the following discipline areas: gamma ray astronomy, X-ray astronomy, ultraviolet and optical astronomy, infrared and radio astronomy, particle astrophysics, solar physics, interplanetary physics, planetary magnetospheres, and astrochemistry. GSFC is also responsible for conducting the mission operations for a variety of operating spacecraft. Other activities include managing NASA's sounding rocket and scientific balloon program.

GSFC also conducts planetary exploration research into the physics of interplanetary and planetary space environments. Participates in planetary mission instrument development, operations, and data analysis. GSFC develops technologies targeted at improved spaceborne instruments, and on-board spacecraft systems and subsystems.

EARTH SCIENCE - Lead Center for Earth Science, including the Earth Observing System (EOS). The primary objective of the EOS is to record global change and to observe regional-to-global processes. The EOS will document global change over a 15-year period to provide long-term, consistent data sets for use in modeling and understanding global processes. This process and modeling research effort will provide the basis for establishing predictive global change models for policy makers and scientists.

Manages Earth Probes and New Millennium flight projects; and manages, on a reimbursable basis, the acquisition of meteorological observing spacecraft for the National Oceanic and Atmospheric Administration (NOAA). Conducts science correlation measurements from balloons, sounding rockets, aircraft, and ground installations.

Lead Center for the Independent Verification & Validation (IV&V) Facility in Fairmont, West Virginia. The IV&V Facility is responsible for providing independent assessments of project software and for the management of all software IV&V efforts within the Agency.

AERONAUTICAL RESEARCH AND TECHNOLOGY - The Wallops Flight Facility provides institutional and technical support to Langley Research Center, other NASA Centers, and commercial users who conduct flight studies of new approach and landing procedures using the latest in guidance equipment and techniques, pilot information displays, human factors data, and terminal area navigation. As an integral partner in the Agency's High Performance Computing and Communications (HPCC) program, GSFC leads an effort to enhance the infusion of HPCC technologies into the Earth community through the provision of advanced computer architectures and communication technologies. Promotes private sector investment in space-based technologies through the transfer of technologies that derive from NASA's programs and activities.

MISSION/SPACE COMMUNICATION SERVICES - Research and technology involves the investigation and development of advanced systems and techniques for spacecraft communications and tracking, command and control, and data acquisition and processing. The primary objectives are to apply technology and develop advanced capabilities to meet the tracking and data processing requirements of new missions and to improve the cost effectiveness and reliability of flight mission support.

Although the Johnson Space Center is designated as the Space Operations Lead Center, GSFC manages a number of critical program elements, including operation of the Tracking and Data Relay Satellite System (TDRSS); the development of the replenishment TDRSS spacecraft; mission control, data processing, and orbit/attitude computation support; operating the Space Tracking and Data Network (STDN), the NASA Communications (NASCOM) Network, and the Aeronautics, Balloons and Sounding Rocket Program.

The NASCOM Network links the stations of the Deep Space Network (DSN), STDN, TDRSS, and other tracking and data acquisition elements with control centers and data processing and computation centers.

CENTER MANAGEMENT AND OPERATIONS - Provides administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems, and equipment. These functions are distributed under Institutional Support across the different Enterprises. GSFC also performs the following activities for NASA Headquarters: Logistics and transportation support; financial management and all accounting services; procurement support for contracts, grants and cooperative agreements required by Headquarters offices; training and development services; and processing of unsolicited proposals received for review by Headquarters.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
GODDARD SPACE FLIGHT CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**453**	**467**	**460**
International Space Station	1	0	0
Space Operations (SOMO)	236	236	234
Space Flight Operations (Space Shuttle)	8	8	8
Payload & ELV Support	59	58	61
Investment - HEDS	0	1	0
HEDS Mission Support	149	164	157
SPACE SCIENCE	**1,441**	**1,539**	**1,620**
Major Development Programs	249	229	200
Payloads Program	28	20	19
Explorer Program	176	179	184
Mars Surveyor Program	10	23	27
Discovery Program	8	10	9
Operating Missions	0	0	0
Research and Technology	501	590	627
Space Science Mission Support	469	488	554
BIOLOGICAL & PHYSICAL RESEARCH	**0**	**0**	**0**
B&PR Mission Support	0	0	0
EARTH SCIENCE	**1,305**	**1,199**	**1,129**
Earth Observing System Program	384	375	363
Earth Probes Program	139	72	53
Operating Missions	29	27	22
Research and Technology	241	224	227
Earth Science Mission Support	426	422	387
ES Reimbursable Activities	86	79	77

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
GODDARD SPACE FLIGHT CENTER (continued)

	FY 2000	FY 2001	FY 2002
AERO-SPACE TECHNOLOGY	**72**	**94**	**95**
High Speed Research Program	1	0	0
Advanced Subsonics Tech Program	2	0	0
Aero-Space Base	4	10	14
Commercial Technology Program	44	48	47
Aero-Space Technology Mission Support	21	36	34
SAFETY AND MISSION ASSURANCE	**12**	**7**	**7**
Safety and Mission Assurance	12	7	7
ACADEMIC PROGRAMS	**5**	**5**	**5**
Total full-time equivalents (FTEs)	**3,288**	**3,311**	**3,316**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

AMES RESEARCH CENTER

ROLES AND MISSIONS

AERO-SPACE TECHNOLOGY – Ames Research Center (ARC) is the lead for integrative research in information technology, biotechnology and nanotechnology towards applications in NASA's missions. ARC conducts research in aerospace operations automation technologies and modeling with an emphasis on enhancing National Airspace capacity and safety. ARC conducts aerospace vehicle research and technology development associated with autonomy and integrated vehicle health management. ARC conducts research and technology development that supports life cycle risk management and the associated knowledge management systems. ARC provides leadership for high end computing and networking within the Agency. ARC provides high-fidelity flight simulations to support national goals in aviation safety and capacity, as well as aerospace vehicle development requirements. ARC conducts research on advanced thermal protection systems and performs arcjet testing to meet national needs for access to space and planetary exploration. ARC emphasizes joint research and technology projects with academia, industry and other government agencies in order to apply the best talent of the nation to NASA's mission requirements.

SPACE SCIENCE – ARC has the Agency lead role in Astrobiology (the study of life in the universe) which focuses on the origin, adaptation, and destiny of life in the universe. Research includes advanced laboratory and computation facilities for astrochemistry; planetary atmosphere modeling, including relationships to the atmosphere of the Earth; the formation of stars and planetary systems; and an infrared technology program to investigate the nature and evolution of astronomical systems. Development continues of the Stratospheric Observatory for Infrared Astronomy (SOFIA) for research to be conducted by various NASA/university teams. Research and development in advanced information technologies are directed toward significantly increasing the efficiency of SOFIA as it becomes operational. ARC is the lead Center for information technology efforts in the cross-enterprise spacecraft technology program.

LIFE AND MICROGRAVITY SCIENCE - ARC has the Agency lead role in Fundamental Biology program and the Biomolecular Systems Research program. These synergistic programs examine the adaptation of life forms to reduced gravity and the biotechnology which supports this scientific pursuit. Research continues into the effects of gravity on living systems using spaceflight experiments, ground simulation, and hypergravity facilities to understand how gravity affects the development, structure, and functions of living systems. Development continues on the Space Station Biological Research Project, the key life science facility aboard the International Space Station. Also studied are options for preventing problems in crew health and psychophysiology during and after extended spaceflight. ARC has a primary focus on advanced physical/chemical technologies for life support, including research into all aspects of regenerative life support. Research is conducted in the areas of ecosystems and health monitoring.

EARTH SCIENCE - ARC builds instruments and computer models for the measurement and analysis of atmospheric constituents and properties from aircraft platform are being developed. Applied research and developments to enhance the use of remote and in-situ sensing technology for Earth resources applications continues. ARC provides information systems and high end computing support for Earth Sciences knowledge acquisition.

SAFETY AND MISSION ASSURANCE - Provide institutional safety and health programs and develop and integrate Safety and Mission Assurance guidelines into program and project development. ARC has created a Systems Management function to assist programs and projects in their initial development phase to ensure their successful implementation.

CENTER MANAGEMENT AND OPERATIONS - Provide administrative and financial services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems, and equipment. ARC is ISO 9001 certified. These functions are distributed under Institutional Support across the different Enterprises.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
AMES RESEARCH CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**87**	**89**	**119**
International Space Station	64	67	97
Space Flight Operations (Space Shuttle)	1	0	0
HEDS Mission Support	22	22	22
SPACE SCIENCE	**288**	**195**	**194**
Major Development Programs	54	49	38
Mars Surveyor Program	11	11	9
Research and Technology	150	87	99
Space Science Mission Support	73	48	48
BIOLOGICAL & PHYSICAL RESEARCH	**82**	**81**	**77**
Biological & Physical Research	60	59	59
B&PR Mission Support	22	22	18
EARTH SCIENCE	**74**	**73**	**73**
Research and Technology	56	55	55
Earth Science Mission Support	18	18	18
AERO-SPACE TECHNOLOGY	**908**	**1,015**	**1,012**
Aero-space Focused Programs	229	225	223
Aero-Space Base	440	401	355
Commercial Technology Program	17	16	16
Space Base Program	0	56	75
Aero-Space Technology Mission Support	222	317	343
SAFETY AND MISSION ASSURANCE	**3**	**2**	**2**
Safety and Mission Assurance	3	2	2
ACADEMIC PROGRAMS	**9**	**9**	**9**
Total full-time equivalents (FTEs)	**1,451**	**1,464**	**1,486**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2002 ESTIMATES

DRYDEN FLIGHT RESEARCH CENTER

CENTER ROLES AND MISSIONS

AEROSPACE TECHNOLOGY - Develop, manage, and maintain facilities and test bed aircraft to support safe, timely, and cost effective NASA flight research and to support industry, university, and other government agency flight programs.

Conceive, formulate, and conduct piloted and unpiloted research programs in disciplinary technology, integrated aeronautical systems, and advanced concepts to meet current and future missions throughout subsonic, supersonic, and hypersonic flight regimes.

Conduct flight research programs in cooperation with other NASA Installations, other government agencies, the aerospace industry, and universities. Provides for the timely transition of results, techniques, methods, and tools to industry and government users.

DFRC will also provide flight test support for atmospheric tests of experimental or developmental launch systems, including reusable systems.

INTERNATIONAL SPACE STATION – Conduct technology development and flight test of a X-38 prototype emergency Crew Return Vehicle (CRV), provide on-orbit tracking and communications through Western Aeronautical Test Range (WATR).

SPACE SHUTTLE /PAYLOAD AND UTILIZATION OPERATIONS AND SPACE MANAGEMENT OPERATIONS OFFICE (SOMO) - Provide operational and technical support for the conduct of Space Shuttle missions, including on-orbit tracking and communications (WATR), landing support of crew and science requirements.

EARTH SCIENCE - Conduct flight operations in support of Airborne Science Missions utilizing aircraft for data collection and observation.

CENTER MANAGEMENT AND OPERATIONS - Provides administrative services in support of Center management and provides for the operation and maintenance of the institutional facilities, systems, and equipment. These functions are distributed under Institutional Support across the different Enterprises.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
DRYGEN FLIGHT RESEARCH CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**76**	**62**	**133**
International Space Station	33	33	103
Space Operations (SOMO)	19	9	10
Space Flight Operations (Space Shuttle)	4	4	4
HEDS Mission Support	20	16	16
EARTH SCIENCE	**38**	**37**	**38**
Research and Technology	29	29	29
Earth Science Mission Support	9	8	9
AERO-SPACE TECHNOLOGY	**500**	**533**	**435**
Aero-space Focused Programs	79	172	95
Aero-Space Base	289	224	202
Commercial Technology Program	3	3	3
Aero-Space Technology Mission Support	129	134	135
SAFETY AND MISSION ASSURANCE	**1**	**1**	**1**
Safety and Mission Assurance	1	1	1
ACADEMIC PROGRAMS	**2**	**2**	**2**
Total full-time equivalents (FTEs)	**617**	**635**	**609**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2002 ESTIMATE

LANGLEY RESEARCH CENTER

ROLES AND MISSIONS

AERO-SPACE RESEARCH AND TECHNOLOGY - Conduct advanced research in fundamental airframe systems technologies including aerodynamics; high-speed, highly maneuverable aircraft; hypersonic propulsion; guidance and controls; acoustics; and structures and materials. Develop a technology base for improving transport, fighter, general aviation, and commuter aircraft. Conduct an aeronautical research and technology program to study current and future technology requirements and to demonstrate technology applications. Conduct theoretical and experimental research in fluid and flight mechanics to determine aerodynamic flows and complex aircraft motions.

Initiate a new vehicle research thrust to explore advanced vehicle concepts and revolutionary new technologies to enable the development of advanced 21st Century Air Vehicles. Conduct research to develop new technologies such as advanced aeroelastically tailored materials, new structural concepts, embedded sensors, intelligent systems, and microactuators. Employ advanced analysis methods to combine these new technologies to develop innovative new airframe systems with improved safety, reduced emissions and noise, increased capacity, and reduced cost per seat mile for commercial transport and general aviation aircraft. Conduct control and guidance research programs to advance technology in aircraft guidance and navigation, aircraft control systems, cockpit systems integration and interfacing techniques, and performance validation and verification methods. Provide Agencywide leadership and strategically maintain or increase the Agency's preeminent position in structures and materials by serving as the NASA Center of Excellence for Structures and Materials.

Conduct aeronautics and space research and technology development for airframe systems to advance aerospace transportation systems, including hypersonic aircraft, missiles, and space access vehicles using airbreathing and rocket propulsion. Conduct research to develop airframe technologies and capabilities for next generation reusable launch vehicles and to develop aeroassist technologies and capabilities to enable safer and more affordable spacecraft. Specific technology discipline areas of expertise are aerodynamics, aerothermodynamics, structures, materials, hypersonic propulsion, guidance and controls, and systems analysis. Conduct long-range studies directed at defining the technology requirements for advanced transportation systems and missions. Develop technology options for realization of practical hypersonic and transatmospheric flight.

EARTH SCIENCE - Perform an Agency-designated Atmospheric Science mission role in support of the Earth Science Enterprise in the NASA Strategic Plan. As Lead Center for Focused Atmospheric Science Missions, conduct a world-class peer reviewed and selected atmospheric science program in support of national goals in preserving the environment and in fundamental science. Specific discipline areas of expertise are Earth radiation research, particularly the role of clouds in the Earth's energy budget; middle and upper atmospheric research; and troposhperic research. Perform innovative scientific research to advance the knowledge of atmospheric radioactive, chemical, and dynamic processes for understanding global change; develop innovative passive and active sensor systems concepts for atmospheric science measurements. Conduct a technology development program that develops advanced laser and LIDAR technologies for Earth science missions; advanced passive remote sensing technologies; develop advanced ultra-lightweight and adaptive materials, structural systems technologies, and analytical tools for significantly reducing the end-to-end cost and increasing the performance of earth observation space instruments and systems. Conduct an Application and Educational Outreach program that utilizes scientific data for non-scientific applications and in support of science and math education. Serve as a Primary Data Analysis and Archival Center (DAAC) for Earth Radiation and Atmospheric Chemistry for the Earth Observing System.

SPACE SCIENCES - Support the solicitation and selection process of the Office of Space Science's (OSS) Discovery, Explorer, and Solar Terrestrial Probes Programs; conduct reviews of candidate and selected missions and independent assessments of on-going space science missions to help ensure that OSS criteria for high quality science return within cost and schedule constrains are met. Conduct a technology development program for advanced ultra-lightweight and adaptive materials, structural systems technologies, and analytical tools for significantly reducing the end-to-end cost and increasing the performance of space science instruments and systems. Continue studies and selected technology development for future planetary atmospheric flight vehicles including aeroshells, airplanes, gliders, etc. Develop active and passive sensor technologies and concepts for application in planetary atmospheric studies. Selectively develop laser, LIDAR, and passive sensor technologies and perform research for planetary studies in areas which are related to our Earth Science role. LaRC has provided and continues to provide analysis of spacecraft aerodynamics, aerothermodynamics, and flight dynamics for spacecraft entering planetary atmospheres (including Earth) in support of both spacecraft design and flight operations. LaRC is also responsible for the design and development of the Earth Entry Vehicle technology flight demonstration for the Mars Sample Return Mission currently scheduled for test in 2006.

LIFE AND MICROGRAVITY SCIENCES - Conduct space radiation exposure studies and develop/upgrade analysis tools and new materials in support of current and future human space efforts for a more accurate assessment of astronaut radiation exposures and body shielding factors.

HUMAN EXPLORATION AND DEVELOPMENT OF SPACE - Support the Human Exploration and Development of Space through systems analyses of Space Station evolution and future human space exploration missions.

SYSTEMS ANALYSIS/INDEPENDENT PROGRAM EVALUATION AND ASSESSMENT - Serve as the Agency lead Center for systems analysis and the conduct of independent evaluation, assessment, and cost estimation of Agency programs. Maintain, as a Center core competency, appropriate expertise and analysis tools to support the Agency's Strategic Enterprises in the definition and development of advanced systems concepts to achieve NASA's goals. Utilize core systems analysis capabilities (supplemented with expertise from other Centers as appropriate) to support the Office of the Administrator by conducting independent assessments of advanced concepts and proposed new systems to validate conceptual level designs prior to Agency commitment to major developmental funding. Provide Agency-wide independent cost estimates and analysis for programs and projects. Support the Administrator's Program Management Council (PMC) in the organization, administration, and technical support of PMC review process.

CENTER MANAGEMENT AND OPERATIONS - Provide for the safety and security of the Center workforce and for the safe operation and maintenance of the institutional facilities, systems, and equipment. Provide administrative and financial services in support of Center management. These functions are distributed under Institutional Support across the different Enterprises.
Langley also is the lead for the Independent Program Analysis Office (including cost assessments) for the entire agency.

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
LANGLEY RESEARCH CENTER

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**49**	**25**	**59**
International Space Station	30	21	55
Payload & ELV Support	11	0	0
HEDS Mission Support	8	4	4
SPACE SCIENCE	**143**	**87**	**101**
Major Development Programs	15	1	0
Payloads Program	4	1	1
Mars Surveyor Program	35	53	61
Discovery Program	7	6	11
Operating Missions	5	0	0
Research and Technology	53	9	10
Space Science Mission Support	24	17	17
BIOLOGICAL & PHYSICAL RESEARCH	**0**	**3**	**3**
Biological & Physical Research	0	3	3
B&PR Mission Support	0	0	0
EARTH SCIENCE	**351**	**307**	**304**
Earth Observing System Program	75	46	42
Earth Probes Program	13	27	23
Operating Missions	1	6	6
Research and Technology	203	170	178
Earth Science Mission Support	59	57	56
AERO-SPACE TECHNOLOGY	**1,813**	**1,943**	**1,866**
Aero-space Focused Programs	449	534	452
Aero-Space Base	883	926	948
Commercial Technology Program	42	61	66
Code R New Initiative	130	0	0
Space Base Program	0	63	50
Aero-Space Technology Mission Support	309	359	350

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
LANGLEY RESEARCH CENER (continued)

	FY 2000	FY 2001	FY 2002
SAFETY AND MISSION ASSURANCE	**4**	**32**	**32**
Safety and Mission Assurance	4	32	32
Total full-time equivalents (FTEs)	**2,360**	**2,396**	**2,364**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

GLENN RESEARCH CENTER at LEWIS FIELD

ROLES AND MISSIONS

LIFE AND MICROGRAVITY SCIENCES - The Glenn Research Center (GRC) provides leadership and management of the fluid physics, combustion science, and acceleration measurement disciplines of NASA's Microgravity Science Program. Sponsors and conducts ground-based scientific studies that may lead to experiments in space. GRC has a substantial effort in the design, buildup, testing, integration, and telescience operations of hardware for experiments to be launched aboard the Space Shuttle and the utilization of the Space Station for scientific missions.

SPACE STATION - GRC support to the space station program includes technical and management support in the areas of power and on-board propulsion components and system, engineering and analysis, technical expertise, and testing for components and systems. This includes use of facilities and testbeds and construction of flight hardware as required.

MISSION COMMUNICATIONS SERVICES - GRC develops and demonstrates communications and networks technologies in relevant environments to enhance the performance of existing mission services or enable new services. The Center identifies and infuses new capabilities at higher frequencies (Ka-band and above) into the next generation of spacecraft and communications satellites, to enable seamless interoperability between NASA assets and commercial space and ground networks. The Center also ensures timely and high quality availability of radio frequency spectrum to enable the realization of NASA goals.

AERONAUTICAL RESEARCH AND TECHNOLOGY - As the NASA Lead Center for Aeropropulsion, GRC conducts world-class research critical to the Agency Aerospace Technology Enterprise goals of developing and transferring enabling technologies to U.S. Industry and other government agencies. The Center's Aeropropulsion programs are essential to achieving National goals to promote economic growth and national security through safe, superior, and environmentally compatible U.S. civil and military aircraft propulsion systems.

AEROSPACE PROPULSION AND POWER - The Aerospace Propulsion and Power Base R&T Program provides a foundation for the broad range of technologies needed for a steady influx of concepts available for use by the U.S. aerospace industry through the future years. It supports the Enterprise goals by providing a foundation to enable the following:

- Develop advanced technology concepts and methodologies for application by industry;
- Build foundation for focused programs to address selected national needs;
- Respond quickly to critical safety and other issues; and
- Provide facilities and expert consultation for industry during their product development

The Aerospace Propulsion and Power Base R&T program spans subsonic, supersonic, hypersonic, general aviation, high performance aircraft, and access-to-space propulsion systems through research in combustion, turbomachinery, materials and structures, internal fluid dynamics, instrumentation and controls, interdisciplinary technologies, and aircraft icing.

Another Lead-Center program, Ultra-Efficient Engine Technology, is planned and designed to develop high-payoff, high-risk technologies to enable the next breakthroughs in propulsion systems to spawn a new generation of high performance, operationally efficient and economical, reliable and environmentally compatible U.S. aircraft. The breakthrough technologies are focused on propulsion component and high temperature engine materials development and demonstrations enabling future commercial and military propulsion systems which are greatly simplified, achieve higher performance, and have potential for much reduced environmental impact with a broad range of aircraft application.

GRC has research expertise in world-class facilities critical to ensuring U.S. leadership in aviation. The FAA, EPA, and DOD in particular depend on NASA GRC research for advancement in emissions, noise, engine performance, and new materials.

NASA Center of Excellence in Turbomachinery GRC's expertise in Turbomachinery is critical to advancing the Agency's goals in the aeronautics and space programs. This enables GRC to be a cost-effective resource across multiple Agency programs in the vital and strategic discipline area of turbomachinery. Turbomachinery based areas of expertise include air breathing propulsion and power systems, primary and auxiliary propulsion and power systems, on-board propulsion systems, and rotating machinery for the pumping of fuels/propellants.

CENTER MANAGEMENT AND OPERATIONS - Provides administrative and financial services in support of Center Management and provides for the operation and maintenance of the institutional facilities, systems, and equipment. These functions are distributed under Institutional Support across the different Enterprises

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
GLENN RESEARCH CENTER at LEWIS FIELD

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**323**	**349**	**441**
International Space Station	207	213	286
Space Operations (SOMO)	48	56	61
HEDS Mission Support	68	80	94
SPACE SCIENCE	**217**	**15**	**16**
Research and Technology	169	12	12
Space Science Mission Support	48	3	4
BIOLOGICAL & PHYSICAL RESEARCH	**149**	**118**	**108**
Biological & Physical Research	115	93	84
B&PR Mission Support	34	25	24
EARTH SCIENCE	**1**	**3**	**3**
Research and Technology	1	3	3
AERO-SPACE TECHNOLOGY	**1,265**	**1,475**	**1,341**
Aero-space Focused Programs	294	361	315
Aero-Space Base	694	627	578
Commercial Technology Program	27	24	24
Space Base Program	0	178	153
Investment - AST	10	9	9
Aero-Space Technology Mission Support	240	276	262
SAFETY AND MISSION ASSURANCE	**15**	**13**	**13**
Safety and Mission Assurance	15	13	13
Total full-time equivalents (FTEs)	**1,970**	**1,973**	**1,922**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 2002 ESTIMATES

NASA HEADQUARTERS

ROLES AND MISSIONS

NASA Corporate Headquarters

MISSION - The mission of Headquarters is to plan and provide executive direction for the implementation of U. S. space exploration, space science, Earth science, aeronautics, and technology programs. This includes corporate policy development, program formulation, resource allocations, program performance assessment, long-term institutional investments, and external advocacy for all of NASA.

MAJOR CORPORATE ROLES - At NASA Headquarters, the broad framework for program formulation will be conducted through five Strategic Enterprises: Human Exploration and Development of Space, Earth Science, Aerospace Technology, Biological and Physical Research, and Space Science. Consistent with the NASA strategic plan, the Strategic Enterprises develop program goals and objectives to meet the needs of external customers within the policy priorities of the Administration and Congress.

Corporate level enabling processes and staff functions will provide cross-cutting interfaces required to support the Strategic Enterprises in legislative affairs, public affairs, budget and financial management, equal opportunity programs, human resources, education, legal affairs, procurement, international affairs, management systems and facilities, information systems and technology, small business, safety and mission quality, advisory committees, and policy and plans. These functions are distributed under Institutional Support across the different Enterprises

DISTRIBUTION OF FULL-TIME EQUIVALENT (FTE) WORKYEARS BY PROGRAM
NASA HEADQUARTERS

	FY 2000	FY 2001	FY 2002
HUMAN EXPLORATION & DEVELOPMENT OF SPACE	**403**	**457**	**496**
HEDS Mission Support	403	457	496
SPACE SCIENCE	**127**	**117**	**127**
Space Science Mission Support	127	117	127
BIOLOGICAL & PHYSICAL RESEARCH	**29**	**32**	**35**
B&PR Mission Support	29	32	35
EARTH SCIENCE	**98**	**96**	**92**
Earth Science Mission Support	98	96	92
AERO-SPACE TECHNOLOGY	**323**	**361**	**404**
Aero-Space Technology Mission Support	323	361	404
Total full-time equivalents (FTEs)	**980**	**1,063**	**1,154**

Note: Staffing distribution for FY 2001 and FY 2002 is under review in response to cost growth on the Space Station Program and the need for management reforms. Civil Service workforce distribution is being assessed to focus on agency priorities, and the numbers provided may be subject to change

The allocation of FTEs for Mission Support at Headquarters is determined by a formula based on the proportion of total civil service FTEs associated with each Enterprise across all NASA Centers. The numbers above do not reflect the number of direct FTEs at NASA Headquarters in each of the Enterprise offices since the function of HQ personnel is considered to be "corporate" in nature, supporting the entire Agency. The derivation for these FTEs is similarly used to distribute the cost of the NASA Headquarters civil servants to the Enterprises.

DETAIL OF PERMANENT POSITIONS

	FY 2000	FY 2001	FY 2002
Executive level II	1	1	1
Executive level IV	1	2	2
Subtotal	**2**	**3**	**3**
ES-6	36	41	46
ES-5	67	90	95
ES-4	120	146	151
ES-3	47	75	80
ES-2	57	75	65
ES-1	66	78	68
Subtotal	**393**	**505**	**505**
CA	1	1	1
SL/ST	62	62	62
GS-15	2,544	2,566	2,566
GS-14	3,698	3,743	3,743
GS-13	5,662	5,745	5,745
GS-12	1,762	1,793	1,793
GS-11	1,284	1,303	1,303
GS-10	214	217	217
GS-9	507	525	535
GS-8	282	298	298
GS-7	654	676	666
GS-6	419	422	422
GS-5	85	89	89
GS-4	30	32	32
GS-3	4	2	2
GS-2	0	0	0
Subtotal	**17,208**	**17,474**	**17,474**
Special ungraded positions established by NASA Administrator	22	26	26
Ungraded positions	229	229	229
Total permanent positions	**17,854**	**18,237**	**18,237**
Unfilled positions, EOY	0	0	0
Total, permanent employment, EOY	**17,854**	**18,237**	**18,237**

PERSONNEL SUMMARY

	FY 2000	FY 2001	FY 2002
Average GS/GM grade	12.57	12.54	12.53
Average ES salary	$126,046	$128,693	$131,396
Average GS/GM salary	$70,016	$72,956	$76,021
Average salary of special ungraded positions established by NASA Administrator	$88,277	$91,985	$95,848
Average salary of ungraded positions	$47,554	$49,551	$51,632

CENTER LOCATIONS AND CAPITAL INVESTMENT

JOHNSON SPACE CENTER - The Lyndon B. Johnson Space Center is located 20 miles southeast of Houston, Texas. NASA owns 1,581 acres of land at the Houston site and uses another 60,552 at the White Sands Test Facility, Las Cruces, New Mexico. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $2,337,142 as of September 30, 2000.

KENNEDY SPACE CENTER - The Kennedy Space Center is located 50 miles east of Orlando, Florida. NASA owns 82,943 acres and uses launch facilities at Cape Canaveral Air Station and Vandenberg Air Force Base. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $1,759,599 as of September 30, 2000.

MARSHALL SPACE FLIGHT CENTER - The Marshall Space Flight Center is located within the U.S. Army's Redstone Arsenal at Huntsville, Alabama. MSFC also manages operation at the Michoud Assembly 15 miles east of New Orleans, Louisiana and the Slidell Computer Complex in Slidell, Louisiana. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $2,941,841 as of September 30, 2000.

STENNIS SPACE CENTER - The Stennis Space Center is located approximately 50 miles northeast of New Orleans, Louisiana. NASA owns 20,663 acres and has easements covering an additional 118,284 acres. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $467,857 as of September 30, 2000.

GODDARD SPACE FLIGHT CENTER - The Goddard Space Flight Center is located 15 miles northeast of Washington, D.C. at Greenbelt, Maryland. NASA owns 1,121 acres at this location and an additional 6,176 acres at the Wallops Flight Facility in Wallops Island, Virginia. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets at both locations was $1,818,345 as of September 30, 2000.

AMES RESEARCH CENTER - The Ames Research Center is located south of San Francisco on Moffett Field, California. NASA owns 447.5 acres at the Moffett Field location. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets at both locations was $1,044,818 as of September 30, 2000.

DRYDEN FLIGHT RESEARCH CENTER - The Dryden Flight Research Center is 65 air miles northeast of Los Angeles. Dryden is located at the north end of Edwards Air Force Base on 838 acres of land under a permit from the Air Force. The total capital investment at Dryden, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 2000 was $1,283,196.

LANGLEY RESEARCH CENTER - The Langley Research Center is adjacent to Langley Air Force Base which is located between Williamsburg and Norfolk at Hampton, Virginia. NASA owns 788 acres and has access to 3,276 acres. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets was $1,024,116 as of September 30, 2000.

GLENN RESEARCH CENTER - The Lewis Research Center occupies two sites; the main site is in Cleveland, Ohio, adjacent to Cleveland-Hopkins Airport; the second site is the Plum Brook Station located south of Sandusky, Ohio, and 50 miles west of Cleveland. NASA owns 6,805 acres and leases an additional 14 acres at the Cleveland location. The total capital investment including land, buildings, structures and facilities, equipment, and other fixed assets at both locations was $648,089 as September 30, 2000.

NASA HEADQUARTERS - NASA Headquarters is located at Two Independence Square, 300 E St. SW, Washington, D.C. and occupies other buildings in the District of Columbia, Maryland, and Virginia.

MISSION SUPPORT

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF MANAGEMENT SYSTEMS **CONSTRUCTION OF FACILITIES**

SUMMARY OF RESOURCES BY APPROPRIATION

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Human Space Flight	16,376	15,865	17,300	MS 4-8
Science, Aeronautics and Technology	27,200	34,738	43,800	MS 4-14
*Mission Support	179,100	279,481	232,200	MS 4-20
Total	222,676	330,084	293,300	

**Beginning in FY 2002, Construction of Facilities contained within the Mission Support account will be allocated to the Human Space Flight (HSF) and the Science, Aeronautics and Technology (SAT) accounts based on the number for full time equivalent personnel within each Enterprise.*

PROGRAM GOALS

The goal of the Construction of Facilities (CoF) program is to ensure that the facilities critical to achieving NASA's space and aeronautics programs are constructed and continue to function effectively, efficiently, and safely, and that NASA installations conform with requirements and initiatives for the protection of the environment and human health.

STRATEGY FOR ACHIEVING GOALS

NASA facilities are critical to the shuttle, sustaining payload and launch operations, and for providing critical national aeronautical and aerospace testing capabilities, which support NASA, military and private industry users. NASA has conducted a thorough review of its facilities infrastructure finding that the deteriorating plant condition warrants an increased repair and renovation rate to avoid safety hazards to personnel, facilities, and mission; and that some dilapidated facilities need to be replaced. Increased investment in facility revitalization is needed to maintain a facility infrastructure that is safe and capable of supporting NASA's missions. The Budget supports facilities funding to address these needs.

The Construction of Facilities (CoF) budget line item within Mission Support provides for discrete projects required for components of NASA's basic infrastructure and institutional facilities. Beginning in FY 2002, the funding contained within Mission Support will be allocated to the Human Space Flight (HSF) and Science, Aeronautics and Technology (SAT) accounts based on the number for full time equivalent personnel within each Enterprise. Almost all of these projects are capital repair. Mission Support also includes Minor Revitalization and Construction projects (projects greater than $500 thousand but not over $1.5 million), the design of facilities projects, and advanced planning related to future facilities needs. Funding for construction projects required to conduct specific HSF or SAT programs/projects is included in the appropriate budget line item. Descriptions and cost estimates are shown as part of the Construction of Facilities program to provide a complete picture of NASA's budget requirement for facilities.

Within the Human Space Flight appropriations account, the Space Shuttle FY 2002 budget request includes Discrete projects to restore the low voltage power system and refurbish the flame deflector and trench of Pad B at Kennedy Space Center; replace the chilled water, steam, and condensate systems of buildings 110 and 114 at Michoud Assembly Facility; and repair and modernize the A-Complex at Stennis Space Center. It also includes minor projects less than $1.5 million required to support specific programs. The Science, Aeronautics, and Technology appropriations account includes budget requests for discrete projects in: Space Science, to continue construction of the Beam Wave Guide antenna in Madrid, Spain; in Space Science and Earth Science, for a Flight Projects Center at the Jet Propulsion Lab; in Aerospace Technology, to construct a Rocket-Based Combined Cycle Test Facility at the Stennis Space Center; and in Biological and Physical Research, to continue construction of the Booster Applications Facility at Brookhaven National Laboratory.

The institutional projects that are shown as "Mission Support" in FY 2002 are for discrete projects to repair and modernize deteriorating and obsolete building and utility systems that have reached or exceeded their normal design life, are no longer operating effectively or efficiently, and cannot be economically maintained. These systems include mechanical, structural, cooling, steam, electrical distribution, sewer, and storm drainage at Ames Research Center, Dryden Flight Research Center, Glenn Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Johnson Space Center, Langley Research Center, Marshall Space Flight Center, Michoud Assembly Facility, and Wallops Flight Facility. Also included is a project to connect the Madrid Deep Space Communications Complex to commercial Power; two projects to replace old dilapidated trailers and boxcars with new facilities at Kennedy Space Center, and a project to restore the parkway bridge at Goddard Space Flight Center. Should residual resources become available from these projects, they will be used for urgently needed facility revitalization requirements. Congress will be notified before work is initiated for any such project that exceeds $1.5 million.

The Minor Revitalization and Construction program included in this request continues the vital rehabilitation, modification, and repair of facilities to renew and help preserve and enhance the capabilities and usefulness of existing facilities and ensure the safe, economical, and efficient use of the NASA physical plant. The Minor Revitalization and Construction program also replaces substandard facilities in cases where it is more economical to demolish and rebuild than it is to restore. In selected cases, additional square footage may be built when there are compelling reasons to support new or specialized technical and/or institutional requirements of a nature that cannot be provided by using existing facilities.

Funds requested for Facility Planning and Design cover advance planning and design requirements for potential future projects, preparation of facility project design drawings and bid specifications, master planning, facilities studies, and engineering reports and studies. Also included are critical functional leadership activities directed at increasing the rate of return of constrained Agency resources while keeping the facility infrastructure safe, reliable, and available.

Mission Support also includes the Environmental Compliance and Restoration (ECR) Program, which is critical to ensuring that statutory and regulatory environmental requirements and standards are met. NASA's environmental strategy demonstrates our commitment to protect the environment and provides for the protection and safety of human health. This commitment is achieved by focusing and directing our leadership and efforts into the principal areas of environmental compliance, remediation, restoration and conservation, and prevention. The requested funds cover environmental activities required for compliance with environmental statutory and regulatory requirements and standards, orders, regulatory and cooperative agreements and support of environmental program initiatives, including the decommissioning of the Plumbrook Reactor.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
HUMAN SPACE FLIGHT	16,376	15,865	17,300	
INTERNATIONAL SPACE STATION	4,056	---	---	
Space Experiment Research & Processing Laboratory (SERPL)	3,000	---	---	
Facility Planning and Design	1,056	---	---	
SPACE SHUTTLE	11,000	15,466	14,500	
Refurbish Pad B Flame Deflector and Trench (KSC)	---	---	2,200	MS 4-9
Restore Low Voltage Power System, Pad B (KSC)	---	---	2,000	MS 4-10
Replace Chilled Water, Steam, and Condensate Systems (110, 114) (MAF)	---	---	1,900	MS 4-11
Repair and Modernize A-Complex (SSC)	---	---	3,000	MS 4-13
Repair and Upgrade Substations 20A/20B (MAF)	---	1,796	---	
Restore Pad Surfaces and Slopes, Pad B (KSC)	1,800	---	---	
Refurbish Vehicle Assembly Building Elevator Controls	2,300	---	---	
Rehabilitate 480V Electrical Distribution System, ET Manufacturing Bldg. (MAF)	1,800	---	---	
Minor Revitalization of Facilities at Various Locations, Not in excess of $1.5 million per project	2,400	10,876	3,900	MS 4-42
Facility Planning and Design	2,700	2,794	1,500	
PAYLOAD AND ELV SUPPORT	1,320	399	2,800	
Minor Revitalization of Facilities at Various Locations, Not in excess of $1.5 million per project	1,000	---	2,700	MS 4-42
Facility Planning and Design	320	399	100	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
SCIENCE, AERONAUTICS, AND TECHNOLOGY	27,200	34,738	43,800	
SPACE SCIENCE	2,500	7,198	20,500	
Construct Flight Projects Center (JPL)	---	---	13,500	MS 4-15
Construct 34-Meter Beam Waveguide Antenna, Madrid, Spain (JPL)	---	5,000	7,000	MS 4-16
Construct Optical Interferometry Development Laboratory (JPL)	2,500	490	---	
Facility Planning and Design	---	1,708	---	
BIOLOGICAL AND PHYSICAL RESEARCH	9,000	8,581	9,800	
Construct Booster Applications Facility, Brookhaven National Laboratory, Phase 5	9,000	8,581	9,800	MS 4-17
EARTH SCIENCE	1,000	---	1,500	
Construct Flight Projects Center (JPL)	---	---	1,500	MS 4-15
Restore Meteorological Development Laboratory (GSFC)	1,000	---	---	
AEROSPACE TECHNOLOGY	14,700	18,460	12,000	
Construct Rocket-Based Combined Cycle (RBCC) Test Facility (SSC)	4,000	9,978	12,000	MS 4-19
Replace Fan Blades, National Full-Scale Aerodynamic Complex (ARC)	3,400	5,987	---	
Construct Propulsion Research Laboratory (MSFC)	---	1,996	---	
Replace Main Drive for 14x22-Foot Subsonic Tunnel (LaRC)	7,300	---	---	
Facility Planning and Design	---	499	---	
SPACE OPERATIONS	---	499	---	
Facility Planning and Design	---	499	---	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
MISSION SUPPORT CONSTRUCTION OF FACILITIES (CoF)				
Restore Electrical Distribution System (ARC)	2,700	8,980	8,900	MS 4-22
Rehabilitate and Modify Central Emergency Generator System (DFRC)	---	---	3,000	MS 4-23
Repair Sanitary Sewer System (GRC)	---	4,390	3,900	MS 4-24
Repair Site Steam Distribution System (GSFC)	2,900	3,991	4,000	MS 4-25
Restore Parkway Bridge (GSFC)	---	---	2,900	MS 4-26
Connect Madrid Deep Space Communications Complex to Commercial Power (JPL)	---	---	2,800	MS 4-27
Rehabilitate Aircraft Hangar, Ellington Field (JSC)	---	---	3,200	MS 4-28
Construct Operations Support Building, Pad A (KSC)	---	---	5,200	MS 4-30
Construct Operations Support Building II, LC-39 Area (KSC)	---	12,971	8,400	MS 4-31
Rehabilitate Atmospheric Sciences Building, 1250 (LaRC)	---	---	2,400	MS 4-32
Repairs to Air Conditioning Systems, Various Facilities (LaRC)	---	---	3,300	MS 4-33
Replace Heater, 20-inch Mach 6 CF4 Tunnel (LaRC)	---	---	3,500	MS 4-34
Rehabilitate Interior of Office and Laboratory Building (MSFC)	---	---	1,800	MS 4-36
Rehabilitate and Modify Productivity Enhancement Complex (MSFC)	---	---	3,600	MS 4-37
Rehabilitate Precision Cleaning Facility (MSFC)	---	---	2,100	MS 4-38
Repair and Upgrade Substations 31, 32, and 33 (MAF)	---	---	2,400	MS 4-39
Replace Roof, External Tank Manufacturing Building (MAF)	---	---	12,000	MS 4-40
Provide 34.5kV Alternate Feed to Substation G (GRC)	---	4,490	---	
Rehabilitate Distributed Control System (GRC)	---	2,994	---	
Restore Chilled Water Distribution System (GSFC)	3,900	4,989	---	
Replace Chillers, Space Flight Operations Facility (JPL)	---	1,796	---	
Upgrade 34M Beam Waveguide Antenna Subnet for KA-Band, Network (JPL)	---	1,896	---	
Rehabilitate Electrical Distribution System, 200 Area, WSTF (JSC)	---	2,495	---	
Construct Operations Support Building, Hypergol Maintenance Facility (KSC)	---	3,293	---	
Construct Operations Support Building, Pad B (KSC)	---	5,189	---	
Repairs to Primary Electrical Power System, (KSC)	---	3,492	---	
Repairs to Electrical Systems, East and West Areas (LaRC)	---	8,980	---	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY OF BUDGET PLAN BY APPROPRIATION AND PROJECT

INSTALLATION AND PROJECT	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
MISSION SUPPORT CoF (Continued)				
Repair and Modernize Fluid Dynamics Vacuum Pump Facility (MSFC)	---	2,594	---	
Replace Roof, Building 4705 (MSFC)	---	1,397	---	
Replace Mechanical Equipment and Roof, Building 350 (MAF)	---	5,588	---	
Upgrade E-Complex Test Capabilities (SSC)	---	17,960	---	
Construct Propulsion Test Operations Facility (SSC)	---	10,477	---	
Repair Storm Drainage System (WFF)	---	2,694	---	
Rehabilitate Hangar, Building 4802 (DFRC)	2,900	---	---	
Rehabilitate High Voltage System (GRC)	7,600	---	---	
Upgrade 70M Antenna Servo Drive, 70M Antenna Subnet (JPL)	3,400	---	---	
Rehabilitate Utility Tunnel Structure and Systems (JSC)	5,600	---	---	
Connect KSC to CCAS Wastewater Treatment Plant (KSC)	2,300	---	---	
Rehabilitate High Pressure Storage System, LC-39 (KSC)	3,400	---	---	
Replace High Voltage Load Break Switches (KSC)	1,600	---	---	
Repair Roofs, Vehicle Component Supply Buildings (MAF)	2,000	---	---	
Replace Air Storage Field, 8-FT High Temperature Tunnel (LaRC)	10,000	---	---	
Minor Revitalization and Construction of Facilities at Various Locations, Not in excess of $1.5 million per project	77,900	109,256	86,700	MS 4-42
Facility Planning and Design	15,800	15,666	15,100	MS 4-48
Environmental Compliance and Restoration	37,100	43,903	57,000	MS 4-51
(Decommissioning of Plumbrook Reactor, included within ECR (GRC))	3,015	8,800	16,000	MS 4-55
Total Mission Support	179,100	279,481	232,200	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY

HUMAN SPACE FLIGHT

INSTALLATION AND PROJECT	FY 2002 PRES BUDGET (Thousands)	Page Number
Space Shuttle:		
Refurbish LC-39B Flame Deflector and Trench (KSC)	2,200	MS 4-9
Restore Low Voltage Power System, LC-39B (KSC)	2,000	MS 4-10
Replace Chilled Water, Steam, and Condensate Systems (110, 114) (MAF)	1,900	MS 4-11
Repair and Modernize A-Complex (SSC)	3,000	MS 4-13
Minor Revitalization of Facilities at Various Locations, Not in excess of $1.5 million per project	3,900	MS 4-42
Facility Planning and Design	1,500	
Payload and ELV Support:		
Minor Revitalization of Facilities at Various Locations, Not in excess of $1.5 million per project	2,700	MS 4-42
Facility Planning and Design	100	
Total Human Space Flight	17,300	

PROJECT TITLE: Refurbish LC-39B Flame Deflector and Trench
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Kennedy Space Center
LOCATION: Brevard County, Merritt Island, FL

FY 02 COST ESTIMATE (Thousands of Dollars):	2,200
Project Element:	
Orbiter Flame Deflector	550
SRB Flame Deflector	900
Steel Support Structure	200
Paint Steel Structure	550

PRIOR YEARS FUNDING:	176
Construction	----
Facility Planning and Design	176

PROJECT DESCRIPTION:
This project repairs the refractory concrete on the Solid Rocket Booster (SRB) and Orbiter flame deflectors at Launch Complex 39 Pad B (LC-39B). All of the refractory concrete on the SRB side and selected areas on the Orbiter side of the deflector will be replaced. Deteriorated refractory concrete on the flame trench walls and floors will also be replaced. The corrosion protection of the "toes" of the SRB and Orbiter deflectors will be repaired with reinforced portland cement concrete fill. Corroded structural steel on the flame deflector will be replaced. Structural steel on the flame deflector will be protected with a corrosion control coating.

PROJECT JUSTIFICATION:
The refractory concrete heat protection coating is fracturing from the launch environment, and large sections are breaking out. Structural steel supporting the flame deflector is corroding and deforming the coating support plates. This condition creates a significant risk of generating flying object debris, which can be detrimental to surrounding structures and launch support systems.

IMPACT OF DELAY:
Continued use of this launch pad with its flame deflector in its degrading condition puts the facilities and equipment at the launch pad at risk of serious flying debris damage during blastoffs.

PROJECT TITLE: Restore Low Voltage Power System, LC-39B, Phase 2
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Kennedy Space Center
LOCATION: Brevard County, Merritt Island, FL

FY 02 COST ESTIMATE (Thousands of Dollars):	2,000
Project Element:	
Electrical Substations and power distribution systems	2,000

PRIOR YEARS FUNDING:	1,635
Construction	1,500
Facility Planning and Design	135

PROJECT DESCRIPTION:
This project redesigns the power system at Launch Complex 39 Pad B (LC-39B) to consolidate, balance, and eliminate single point failures identified in the power System Assurance Analysis. Project includes replacement, refurbishment and/or repair of the existing deteriorating facility electrical power distribution system at LC-39B, including substations, switch gear, and power distribution circuits that are obsolete or in need of repair. A project study was performed to help define the obsolete equipment, explore alternate distribution schemes, and provide budget cost estimates. The project has been divided into work packages in which the work of each phase can be accomplished in a reasonably short time frame to lessen launch schedule impacts.

PROJECT JUSTIFICATION:
These electrical systems provide low voltage power to LC-39B. This project is essential to assure safe and reliable electrical power for KSC launch operations; payloads, shuttle, and space station processing; and administration/engineering support activities. Much of the existing electrical power distribution equipment was installed in 1965 during the Apollo era and has exceeded life expectancies. Equipment is obsolete, inefficient, and in need of major repair. Many parts required to maintain the systems are unavailable, and Apollo-era distribution schemes often do not efficiently support Shuttle program loads. Environmental factors of salt air, launch blast, Solid Rocket Booster residue, and extreme temperature changes all contribute to the continuing degradation of the deteriorated LC-39B electrical equipment. If a prime system component fails during pre-flight preparations, the launch schedule may slip. The deteriorated equipment and power cables present a serious risk of injury to maintenance and operation personnel.

IMPACT OF DELAY:
Continued operation of unreliable and unsafe electrical equipment at LC-39B increases the risk of injury to personnel, damage to property, and interruption of payload processing and launch operations. Operations and maintenance costs would stay excessively high. Personnel maintaining antiquated and unsafe electrical distribution equipment would continue to do so at risk of severe injury.

PROJECT TITLE: Replace Chilled Water, Steam, and Condensate Systems
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Michoud Assembly Facility
LOCATION: New Orleans, Orleans Parish, LA

FY 02 COST ESTIMATE (Thousands of Dollars):	1,900
Project Element:	
Site Preparation and Demolition	190
Pipes/Valves and Fittings	900
Motors/Starters/Transmitters	90
Framing/Pipe Supports	80
Coils/Pumps/Circuit Setters	250
Condensate Stations/Fittings	90
Miscellaneous/Equipment Rental	300

PRIOR YEARS FUNDING:	312
Construction	----
Facility Planning and Design	312

PROJECT DESCRIPTION:
This project replaces and reconfigures chilled water, steam and condensate systems to meet current and future equipment requirements. New chilled water supply and return piping will be routed from the mechanical equipment room to the north side of the Vertical Assembly Building (VAB) and to the Building 103 booster pumps and central plant mains. New steam and condensate piping will be routed from the 190 Tank Farm area to the north side of the VAB equipment and receiver stations. The project will also provide for the replacement of condensate receiver stations, shut-off valves, strainers, and control valves.

PROJECT JUSTIFICATION:
External Tank (ET) production demands for chilled water, steam, and condensate changed substantially from 1963 (original installation was for production of the Apollo Saturn S1-C booster program). The inability to supply adequate chilled water to reach required temperature/humidity thresholds during an ET production process is a continuing problem which occurs during the hot and humid months of the year. It then becomes necessary to wait hours or days for the ambient conditions to moderate so ET processing activities can proceed in the cells. Chilled water, steam, and condensate return systems are crucial for the continuation of ET operations within the VAB. Chilled water is provided to the air handling units for the dehumidification inside the cells (requires 17%-18% relative humidity for spray operations). Steam/condensate is provided to the air handling units for heating inside the cells (requires 99° F cell environment and 196° supply temperature for tank heating).

The Vertical Assembly Building (VAB) chiller, located in Building 110 Mechanical Equipment Room, provides chilled water to the Building 110 heating, ventilation, air-conditioning (HVAC) systems for the critical cooling and dehumidification parameters within the production cell systems. Chilled water lines connect to the Building 103 plant chilled water system for emergency backup. Steam is supplied from the plant steam system originating from Building 207. Steam/condensate systems are instrumental in providing necessary heating for cell HVAC systems. The HVAC systems utilize this heating means to condition the air entering critical cell environments and also prepare the surface temperature of the ET for foam application. The VAB steam condensate receiver stations and liquid movers for returning hot condensate back to the main Boiler House have also deteriorated. This causes back-ups, leakage, and reduced condensate feedwater for the boilers. Building 110 is the Vertical Assembly Building used for major assembly, Thermal Protection System ablator application, testing, and cleaning of the LH2 and LO2 tanks. Both the chilled water system and the steam/condensate systems were originally installed in 1963, making the majority of the systems almost 40 years old. The chilled water system capacity is unable to meet present year-round demands due to limitations imposed by existing piping system resistance and internal pipe corrosion. Current capacity and flow of chilled water delay ET production processing due to inability to meet stringent environmental parameters. The chiller supplying chilled water to Building 110 operates at full capacity during the summer in an attempt to maintain designed parameters in all critical cell environments.

IMPACT OF DELAY:
Continued degradation of system components and prolonged loss of chilled water, steam, or condensate would impact ET production activities and impact critical ET schedules. Also, delays in ET processing result from increased waiting times required to meet critical temperature and humidity requirements for spray operations in the cells.

PROJECT TITLE: Repair and Modernize A-Complex
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Stennis Space Center
LOCATION: Bay St. Louis, MS

FY 02 COST ESTIMATE (Thousands of Dollars)	3,000
Project Elements:	
Electrical Repair	600
Mechanical Repairs	1,000
Structural Repairs	200
Mechanical Modifications	800
Structural Modifications	400

PRIOR YEARS FUNDING:	13,200
Construction	3,000
Facility Planning and Design	200

PROJECT DESCRIPTION:
This project repairs and modifies the basic infrastructure of the A-1 Test Stand to enable its use for Space Shuttle Maine Engine (SSME) testing. Repairs to mechanical systems such as air system and crane works will be accomplished. Repairs to various structural systems such as the concrete flume, structural steel, barge docks and flame bucket will also be completed. The deluge water supply system will be replaced as well as modification to other piping systems. Repairs to electrical and mechanical systems at the Test Control Center will be performed. Structural and mechanical modifications to A-2 will also be accomplished.

PROJECT JUSTIFICATION:
A-2 is the primary test stand for SSME certifications testing. It is severely over-subscribed and no "downtime" is available to perform significant infrastructure upgrades that are required from a safety and supportability perspective. Upgrading the A-1 test stand to accomplish SSME testing allows these necessary repairs to A-2 to be aggressively pursued in future budgets without impacting program schedules. Completion of this project will allow SSME testing to be transferred to A-1 while A-2 is undergoing its own repairs, and afterwards will provide an on-going backup capability.

The A-Complex is over 30 years old and has not had a significant rehabilitation since the early 1970's. Structural elements of the stand continue to deteriorate due to inaccessibility for routine maintenance. Replacement parts are no longer available for major mechanical and electrical components on the stand. Preliminary risk management assessment indicates this restoration will significantly reduce program risks to safety, schedule, and cost.

IMPACT OF DELAY:
If a failure of facilities should occur on A-2 Test Stand, the SSME program would be delayed with no backup Test Stand (A-1). Delay of the certification testing would impact future Shuttle launch schedules resulting in costs exceeding the cost to restore this complex to a reliable condition. Without the capability to transfer SSME testing to A-1, necessary repairs and upgrades to A-2 cannot be accomplished. This could result in unsafe conditions on the A-2 test stand causing personal injury and equipment loss.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY

SCIENCE, AERONAUTICS, AND TECHNOLOGY

	Amount (Thousands)	Page Number
Space Science		
Construct Flight Projects Center, Phase I (JPL)	13,500	MS 4-15
Construct 34-Meter Beam Waveguide Antenna, Madrid, Spain (JPL)	7,000	MS 4-16
Biological and Physical Research		
Construct Booster Applications Facility, Brookhaven National Laboratory, Phase 4	9,800	MS 4-17
Earth Science		
Construct Flight Projects Center, Phase I (JPL)	1,500	MS 4-15
Aerospace Technology		
Construct Rocket-Based Combined Cycle (RBCC) Test Facility (SSC)	12,000	MS 4-19
Total Science, Aeronautics, and Technology	43,800	

PROJECT TITLE: Construct Flight Projects Center, Phase 1
COGNIZANT OFFICE: Office of Space Science

INSTALLATION: Jet Propulsion Laboratory
LOCATION: La Canada-Flintridge, Los Angeles County, CA

FY 02 COST ESTIMATE (Thousands of Dollars)	15,000
Project Elements:	
Sitework	1,000
Structural	10,000
Architectural	2,000
Mechanical	1,000
Electrical	1,000

PRIOR YEARS FUNDING:	750
Construction	---
Facility Planning and Design	750

PROJECT DESCRIPTION:
This project constructs a 12,000 gross square meter (GSM) building on the southeast corner of Surveyor and Mariner Roads that will provide offices, conference rooms, and support facilities for approximately 800 people. A structural steel framework will support concrete over steel deck floor and roof slabs. The building exterior will be a high performance glass and aluminum curtain wall system with a single ply membrane roof. Heating, ventilating, and air-conditioning (HVAC) and electrical equipment will be modern high efficiency units in fully integrated, digitally controlled systems. Forty-four wooden trailers (2,100 GSM) and six 1940s vintage buildings (4,000 GSM) will be demolished, and approximately 100 parking spaces will be added. We plan to use the Design-Build procurement methodology for this project. A second and final phase estimated at $20 million is required in FY 2003 to complete this facility. Non-construction funding in the amount of $5.5 million will be budgeted to furnish and outfit the building.

PROJECT JUSTIFICATION:
The need to collocate and centralize Flight Program and Project Management functions is vital to the success of JPL missions. Currently, flight program/project personnel are scattered across the Center and in expensive off-site leased space. Approximately 1100 personnel are relocated each year to collocate the skills needed to meet mission requirements. This repetitive movement of personnel costs $3M/year and significantly hinders mission accomplishment. This new building will increase project development efficiency, enhance communications, provide a true teaming environment, provide shared common resources, result in quicker and more efficient dissemination of lessons learned among projects, and allow multiple program/project functions to share experts. The new building will make optimal use of scarce building sites at JPL, ease the over crowded conditions at the Oak Grove campus, and allow demolition of substandard trailers and buildings that are costly to operate and maintain. Missions can be accomplished more effectively, efficiently, and safely while improving employee morale. Expensive off-site leased space will be vacated and the need for additional off-site leases will be avoided. This helps meet NASA's objective to minimized off-site leases. Annual costs of $4-5 million for modular units and off-site leases will be avoided.

IMPACT OF DELAY:
Flight Program and Project Management functions would continue to be accomplished inefficiently with potentially adverse affect to missions. Costly repetitive personnel relocations would still be required. Employees would continue to work in substandard trailers and buildings that are very costly to operate and maintain. Personnel would continue to occupy increasingly expensive off-site leased space, with additional leased space required. Employee effectiveness, efficiency, and moral would continue to be at risk.

PROJECT TITLE: Construct 34-Meter Beam Waveguide Antenna, Phase 2
COGNIZANT OFFICE: Office of Space Science

INSTALLATION: Jet Propulsion Laboratory
LOCATION: Madrid Deep Space Communication Complex (MDSCC), Madrid, Spain

FY 02 COST ESTIMATE (Thousands of Dollars)	7,000
Project Elements:	
Antenna Construction	6,250
Facilities Construction	750

PRIOR YEARS FUNDING:	5,175
Construction	5,000
Facility Planning and Design	175

PROJECT DESCRIPTION:
This project constructs a 34-Meter Beam Waveguide (BWG) Multi-Frequency Antenna at the Madrid Deep Space Communication Complex near Madrid, Spain. The project fabricates and installs the antenna structure, panels, gearboxes, bearings, electric drives, encoders, beam wave-guide mirrors, subreflector and subreflector positioner. It also designs and constructs the foundation and pedestal, as well as all facilities in and around the antenna structure and pedestal. This includes the paved access road; trenches; drainage; flood control devices; water main and distribution system; antenna apron security fence; heating, ventilating, and air-conditioning system; electrical power distribution; fire detection and suppression system; and surveillance system assembly. This is the second and final increment of this $12 million project. The first increment of $5 million is being submitted as a FY 2001 Operating Plan change. Non-construction funding in the amount of $21 million will be budgeted for equipment and outfitting of this facility.

PROJECT JUSTIFICATION:
This project is required to meet the communications data load requirement for the growing number of planned deep space missions. The DSN currently supports the Deep Space Missions of Cassini, Deep Space 1, Galileo, Mars Global Surveyor, Stardust, Ulysses, and Voyager Interstellar. Future missions requiring DSN support include the Mars Missions (Mars Odyssey Orbiter, Mars Twin Orbiters and Rovers, Mars Reconnaissance Orbiter, Mars Mobile Science Lab, Mars Scout, Mars Science Orbiter, Mars Sample Return), Deep Impact, Europa Orbiter, Genesis and Rosetta Orbiter. The tracking commitments of the DSN during the 2003-2004 time frame and approximately every 26 months thereafter require more antenna resources than currently available. This 34 Meter BWG Antenna needs to be operational by November 2003 in order to support the increased network loading which will be placed on the Deep Space Network (DSN) during 2003-2004.

IMPACT OF DELAY:
If this project is not accomplished, the Deep Space Network will be unable to accommodate the scheduled increase in data load required to support the future spacecraft missions currently planned. Without adequate support from the DSN, the deep space missions will be unable to download all the valuable data that each mission is intended to collect.

PROJECT TITLE: Construct Booster Applications Facility, Phase 5
COGNIZANT OFFICE: Office of Biological and Physical Research

INSTALLATION: Brookhaven National Laboratory
LOCATION: Long Island, NY

FY 02 COST ESTIMATE (Thousands of Dollars)	9,800
Project Elements:	
Booster Modifications	1,500
Beam Transport System	2,500
Controls and Personnel Safety System	1,100
Experimental Area Outfitting	1,600
Installation and Services	1,100
Project Services	1,300
Spares	700

PRIOR YEARS FUNDING:	21,381
Construction*	21,381

*Prior year construction funds include Facility Planning and Design and Special Test Equipment

PROJECT DESCRIPTION:

This project constructs a Booster Applications Facility (BAF) adjacent to the existing Brookhaven National Laboratory (BNL) Alternating Gradient Synchrotron (AGS) Booster. Conventional construction includes site clearing and preparation; new roads and parking areas; booster wall penetration; tunnel construction with access/egress corridors at both ends of the tunnel; and construction of two pre-engineered metal buildings, one for protecting power supplies and switchgear, and the other to provide laboratory workspace. The project modifies the AGS Booster to accommodate installation of hardware required to perform slow extraction. Booster modifications include relocation of the beam dump and a wall current monitor; installation of new septum magnets; provision of new power supplies; rewiring for higher currents; and reconfiguration of existing vacuum chambers. The project constructs a 63-meter Beam Transport System (BTS) in the new tunnel capable of providing a 20-degree bend (to eliminate direct line-of-sight) between the booster ring and the target area, and capable of distributing the beam over a 15-centimeter x 15-centimeter target area. The BTS consists of a 10-centimeter diameter vacuum pipe with a thin window in front of the target and a fast-closing valve to protect the booster vacuum from a window break; magnetic elements to transport and shape the beam on target; a cooling system using low conductivity water; and cable trays and cabling for direct current (DC) power and controls. The project includes all distributed systems, central services, and process controls required for operation of the BAF, including a relay-based personnel access control system that permits entrance to radiation areas only when safe to do so. The project upgrades one of the two existing BNL Tandem accelerators to 16 megavolts and modifies it to enable concurrent use by AGS and BAF. The project provides for outfitting of the experimental areas of research in biological systems, including dosimeters, computer systems, and other electronic equipment. Project provides for all supporting infrastructure and utilities. This is the fifth increment of this $34 million project. Construction funds in the amount of $2.8 million will be requested in FY03 to complete the project.

PROJECT JUSTIFICATION:

The BAF will provide a ground-based facility in which to conduct important research aimed at understanding and assessing health risks and developing effective countermeasures against galactic cosmic radiation. Such a capability does not currently exist. The BAF will provide the capability to simulate all major ion components and energies of the galactic cosmic rays and solar proton events. Once the

BAF becomes operational, BNL will provide NASA access to more than 2,000 beam-hours-per-year in order to meet all of the goals of NASA's Strategic Program Plan for Space Radiation Health Research.

The BAF will benefit the International Space Station (ISS) by providing a ground-based facility for meeting operational, scientific, and technology goals in radiation protection. The BAF will provide a capability for accurate calibration of radiation detectors used to monitor crewmember exposures on ISS and verify doses as regulated by OSHA. It will also provide a facility for developing shielding augmentation for ISS, which would increase astronaut safety and extend crew stays. The BAF will enable critical research and measurements for assessing health risks from heavy-ions that comprise up to 50 percent of the biological dose on ISS. Acquiring this scientific knowledge will allow NASA to maximize crew stay times and reduce costs from excessive crew changes.

The National Research Council and the National Council of Radiation Protections and Measurements in independent reviews have informed NASA that the scientific basis to estimate risk from galactic cosmic radiation during long-term space flight does not exist. The BAF will benefit long-duration missions by providing a unique ground-based facility in which to conduct critical research to obtain knowledge of potential health effects and for the development of ground analogs, biological countermeasures, and radiation shielding strategies.

IMPACT OF DELAY:
Deferral or cancellation of this project would greatly impact NASA's ability to pursue vital research on space radiation effects required to enable development of maximum-exposure guidelines and of radiation countermeasures such as shielding. NASA's ability to safely extend crew stays at the ISS and other potential future long-duration space flights would be severely curtailed or eliminated. Delay of this project would also delay our ability to calibrate radiation detectors without which NASA cannot accurately monitor ISS crewmembers' exposure to radiation. These impacts will translate into increased ISS operations cost due to more frequent crew changes, to preclude increased risk to astronauts due to limited knowledge of space radiation effects.

PROJECT TITLE: Construct Rocket Based Combined Cycle (RBCC) Test Facility, Phase 3 INSTALLATION: Stennis Space Center
COGNIZANT OFFICE: Office of Aerospace Technology LOCATION: Bay St. Louis, MS

FY 02 COST ESTIMATE (Thousands of Dollars)	12,000	PRIOR YEARS FUNDING:	13,978
Project Elements:		Construction	12,978
Buildings	1,200	Facility Planning and Design	1,000
Piping and Valves	6,000		
Pressure Vessels	4,800		

PROJECT DESCRIPTION:
This project provides for the design and construction of a “free jet” facility to test up to a 50,000 pounds of thrust rocket engine with a maximum of Mach 0.75 air supply system. Construction will include the sitework, test cell structure, a structure for a Test Control Center (TCC), offices, and a high-bay area for engine preparation and storage. The project will also include installation of gas and cryogenic storage and transfer systems. Project scope includes supporting infrastructure and utilities. This is the third and final increment of this $26 million project.

PROJECT JUSTIFICATION:
The potential benefits of Rocket Based Combined Cycle (RBCC) engines over traditional rocket propulsion have been considered for many years. The primary benefit is the improvement in payload mass fraction resulting in less cost per pound to orbit RBCC technologies must be matured and the maturing process will require ground testing due the complex interactions of chemical kinetics, fluid mechanics and compressible flow effects that occur in RBCC engines.

The RBCC Program requires testing of a rocket engine and possible engine clusters to simulate flight conditions at subsonic conditions. This testing is critical to the engine prototype development and future production testing of the engine. A testing facility is required for sea level testing, sea level free jet testing to Mach 0.75 and altitude testing. No facility is currently available for testing criteria for this type of technology. A Government-owned facility will provide control of facility availability, control of test readiness on a day-to-day basis, and enhanced understanding of the interactions between facility and test article (engine) including air heating and storage systems, thrust measurement systems, and controls and data acquisition systems. The RBCC propulsion test facility will have high productivity goals. Initial estimates are 10 tests per month.

IMPACT OF DELAY:
A delay of this project would prevent development of the technologies necessary to accomplish the Aerospace technologies goal to revolutionize space launch capabilities, reducing payload cost to low-cost orbit by an order of magnitude during the period of 2003-2009 in accordance with the NASA Strategic Plan.

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY OF RESOURCES REQUIREMENTS

MISSION SUPPORT

INSTALLATION AND PROJECT	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET	Page Number
		(Thousands of Dollars)		
Discrete Projects	48,300	110,656	73,400	MS 4-21
Minor Revitalization and Construction	77,900	109,256	86,650	MS 4-42
Facility Planning and Design	15,800	15,666	15,150	MS 4-48
Environmental Compliance and Restoration	37,100	43,903	57,000	MS 4-51
TOTAL	179,100	279,481	232,200	
Distribution of Program Amount by Installation				
Johnson Space Center	17,538	33,451	22,620	
Kennedy Space Center	32,492	48,802	27,960	
Marshall Space Flight Center	21,344	32,232	34,650	
Stennis Space Center	9,930	45,397	10,870	
Ames Research Center	11,901	21,559	21,900	
Dryden Flight Research Center	7,216	5,825	8,500	
Glenn Research Center	19,396	29,800	32,530	
Langley Research Center	19,845	17,952	22,030	
Goddard Space Flight Center	19,780	24,213	22,105	
Jet Propulsion Laboratory	14,372	16,898	24,135	
Headquarters	5,286	3,352	4,900	
TOTAL	179,100	279,481	232,200	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 2002 ESTIMATES

SUMMARY

MISSION SUPPORT

	Amount (Thousands)	Page Number
Mission Support Discrete Projects:		
Restore Electrical Distribution System (ARC)	8,900	MS 4-22
Rehabilitate and Modify Central Emergency Generator System (DFRC)	3,000	MS 4-23
Repair Sanitary Sewer System (GRC)	3,900	MS 4-24
Repair Site Steam Distribution System (GSFC)	4,000	MS 4-25
Restore Parkway Bridge (GSFC)	2,900	MS 4-26
Connect Madrid Deep Space Communications Complex to Commercial Power (JPL)	2,800	MS 4-27
Rehabilitate Aircraft Hangar, Ellington Field (JSC)	3,200	MS 4-28
Construct Operations Support Building, Pad A (KSC)	5,200	MS 4-30
Construct Operations Support Building II, LC-39 Area (KSC)	8,400	MS 4-31
Rehabilitate Atmospheric Sciences Building, 1250 (LaRC)	2,400	MS 4-32
Repairs to Air Conditioning Systems, Various Facilities (LaRC)	3,300	MS 4-33
Replace Heater, 20-inch Mach 6 CF4 Tunnel (LaRC)	3,500	MS 4-34
Rehabilitate Interior of Office and Laboratory Building (MSFC)	1,800	MS 4-36
Rehabilitate and Modify Productivity Enhancement Complex (MSFC)	3,600	MS 4-37
Rehabilitate Precision Cleaning Facility (MSFC)	2,100	MS 4-38
Repair and Upgrade Substations 31, 32, and 33 (MAF)	2,400	MS 4-39
Replace Roof, External Tank Manufacturing Building (MAF)	12,000	MS 4-40
Total Discrete Projects	73,400	

PROJECT TITLE: Restore Electrical Distribution System, Phase 4
COGNIZANT OFFICE: Office of Aerospace Technology

INSTALLATION: Ames Research Center
LOCATION: Moffett Field, Santa Clara County, CA

FY 02 COST ESTIMATE (Thousand of Dollars)	8,900
Project Elements:	
Replace High Voltage Switchgear and Transformers	1,500
Expand Ames Power Monitoring System	1,900
Install Standby Generation	5,500

PRIOR YEARS FUNDING:	14,661
Construction	13,900
Facility Planning and Design	761

PROJECT DESCRIPTION:
This project will modernize and repair the Center's primary electrical distribution system as part of a phased program to improve reliability. This is the fourth of approximately ten phases estimated to cost $50M. This phase replaces medium voltage switchgear and transformers in 13 buildings. Nine of the buildings will get new medium voltage (7.2kV and 13.8kV) switchgear, circuit breakers, transformers; microprocessor based protective relays, and current and potential transformers (CT's and PT's) to allow connection to the new Ames Power Monitoring System. The other four buildings will get new relays, and CT's and PT's. The Ames Power Monitoring System (APMS) will be expanded to provide monitoring of the major office buildings. It will cover approximately 84 buildings with an actual total of approximately 50 hardware points (some of the buildings share the same points.) This phase also installs a 3.2 mega-watt Standby Generation/Un-interruptible Power Supply (UPS) to provide clean and continuous power for the Numerical Aerodynamic Simulation Facility (N258). Fuel storage tanks will be installed to provide extended hours of continuous operation. New 13.8kV switchgear, with the associated CT's, PT's, transformers, and relays will also be installed to interface the UPS to the existing N258 power system.

PROJECT JUSTIFICATION:
The existing 1945 vintage, Center-wide electrical system at Ames is worn out and unreliable. As a result, Ames has experienced increasing instances of power interruptions that have adversely impacted critical research. The old switchgear is unsafe to operate, and it is difficult to maintain because replacement parts are no longer available. New microprocessor based protective relays are more precise which will make for better relay coordination. New potential and current transformers are needed to provide data for the new Ames Power Monitoring System. The existing APMS data transmitted is not dependable and the accuracy of measurement is unpredictable. In addition to previous phases of the APMS task that allowed the monitoring of the major research facilities, this phase will connect the remaining major buildings to provide complete measurement and management of the electrical system at Ames. The APMS is a vital tool in today's rapidly changing and sometimes unreliable electric power supply environment. The Numerical Aerodynamics Simulation (NAS) facility is required to provide services on a 24-hour/7-day basis. Due to the rapidly changing electric power supply landscape, the electric utilities can no longer be depended upon to provide a reliable supply of power for the NAS. A UPS system is the only viable solution to ensure clean and uninterrupted electric power for this vital facility.

IMPACT OF DELAY:
Risk of injury to personnel maintaining hazardous switchgear and transformers would continue. In addition, power outages caused by electrical equipment failure would continue to not only adversely interrupt mission-critical research across the Center, but also prevent the Center from operating in an efficient, cost effective manner.

PROJECT TITLE: Rehabilitate and Modify Central Emergency Generator System
COGNIZANT OFFICE: Office of Aerospace Technology

INSTALLATION: Dryden Flight Research Center
LOCATION: Kern County, CA

FY 02 COST ESTIMATE (Thousands of Dollars)	3,000
Project Elements:	
Generators & Collateral Equipment	1,550
Switchgear	700
Generator Housing	500
Connect to Existing System	200
Testing and Startup	50

PRIOR YEARS FUNDING:	240
Construction	---
Facility Planning and Design	240

PROJECT DESCRIPTION:
This project installs a multi-generator diesel-electric standby power plant along with associated cooling, fueling, and control systems and a dual primary system with redundant switching circuits. Also included are installation of primary/secondary bus and switchgear, power control system, protective relaying, transfer switches and transformers, interconnection with existing distribution system, generator housing to increase lifetime and reduce noise, testing, and startup.

PROJECT JUSTIFICATION:
Dryden's electrical power is supplied by a single 115,000 volt overhead branch pole-line from a commercial utility station over twenty miles away. It flows through an unsheltered transformation/switch station and continues overhead to the Dryden site. The overhead line is exposed to high desert winds, ravens, and hunters using the insulator for target practice causing short circuits. These conditions, plus occasional system-wide problems, cause Dryden to experience several power failures each year, jeopardizing the safety and effectiveness of the Center's flight research mission. The existing 1950's standby generators are obsolete, underpowered, and require manual start-up and synchronization. Dryden has grown tremendously since the 1950's and now has critical research and support operations throughout the site.

IMPACT OF DELAY:
Without this project, the activities of over a thousand people at Dryden would continue to be interrupted by avoidable electrical power failures. Loss of electrical power could jeopardize flight safety and could cause loss of flight research data and even loss of a mission.

PROJECT TITLE: Repair Sanitary Sewer System, Phase 4
COGNIZANT OFFICE: Office of Aerospace Technology

INSTALLATION: Glenn Research Center
LOCATION: Cleveland, OH

FY 02 COST ESTIMATE (Thousands of Dollars)	3,900
Project Elements:	
East Campus Loop	2,500
Building 28 Area Lines	1,400

PRIOR YEARS FUNDING:	4,762
Construction	4,238
Facility Planning and Design	524

PROJECT DESCRIPTION:
This project is the fourth of five phases to repair the aging sanitary sewer system. The scope includes replacing sewer mains, eliminating cross connections between sanitary and storm water systems, and repair/installing oil-water separators. It also includes excavation, backfill, and pavement repair necessary to replace sewer lines and manholes. It will improve the hydraulics of the system, greatly reduce maintenance and operating costs, and eliminate noncompliance discharges to the storm outfalls. Funds will be requested in for phase 5 in the future to restore other segments of the sewer system.

PROJECT JUSTIFICATION:
The existing sanitary sewer system is more than fifty years old and is in poor condition. This project will reduce treatment and maintenance costs associated with operating the aging sanitary sewer system and eliminate nonconformance discharges to storm outfalls. This project will reduce maintenance costs by reducing the need for emergency repairs on broken lines. It will reduce treatment costs by reducing inflow and infiltration into the sanitary sewer. In addition, it will eliminate noncompliance discharges to storm outfalls caused by broken sanitary lines and cross connections to comply with National Pollution Discharge Elimination System permits.

IMPACT OF DELAY:
Without the project, avoidable and costly treatment of storm water discharged through the sanitary sewer system would continue. In addition, continued breaks and blockages in sewer lines are increasingly more likely to occur, requiring costly emergency repairs. Continued noncompliance notices could result in increased inspection, increased monitoring, and fines by the Ohio EPA.

PROJECT TITLE: Repair Site Steam Distribution System, Phase 4
COGNIZANT OFFICE: Office of Earth Science

INSTALLATION: Goddard Space Flight Center
LOCATION: Greenbelt, MD

FY 02 COST ESTIMATE (Thousands of Dollars)	4,000
Project Elements:	
East Campus Loop	1,400
Building 28 Area Lines	900
West Campus West Loop	900
Building Supply Line	300
Mid Campus Loop	500

PRIOR YEARS FUNDING:	9,185
Construction	8,900
Facility Planning and Design	285

PROJECT DESCRIPTION:
This project is the fourth of five phases to repair major portions of the central steam distribution system at Goddard Space Flight Center. The scope includes installing a pipeline loop for the East Campus; replacing pipelines in the vicinity of Building 28; replacing the West Campus pipeline loop; replacing the supply pipelines serving various buildings; and replacing the Mid Campus pipeline loop.

PROJECT JUSTIFICATION:
The central steam distribution system was originally installed in the early 1960s and is at the end of its useful life. The system has deteriorated to the point that corrosion is causing pipes to break and valves to leak. Concrete access portals are deteriorated from steam and condensate leakage causing damage to the surrounding landscape and roadway. The site steam distribution system has become undersized due to substantial growth in buildings and related steam demand. The added steam loads on the East Campus require significant upsizing of the main headers. Some condensate and high-pressure drip lines have failed resulting in waste of water, energy and treatment chemicals. In addition, the leakage of condensate to ground water is in violation of environmental regulations. Extensive insulation failures have resulted in energy losses and damage to site landscaping and pavement. This project will reduce operation and maintenance costs and enhance reliability as well as the ability to maintain the site steam distribution system.

IMPACT OF DELAY:
A major failure could occur in the campus-wide steam distribution system, resulting in the loss of steam supply to several buildings. This would seriously impact critical operations in those buildings that could include spacecraft mission operations and control and spacecraft tracking networks control. The delay will also increase operation and maintenance costs necessary to keep the deteriorated system operational.

PROJECT TITLE: Restore Parkway Bridge
COGNIZANT OFFICE: Office of Earth Science

INSTALLATION: Goddard Space Flight Center
LOCATION: Greenbelt, MD

FY 02 COST ESTIMATE (Thousands of Dollars)	2,900
Project Elements:	
Bridge	2,320
Roadway Approaches	580

PRIOR YEARS FUNDING:	225
Construction	---
Facility Planning and Design	225

PROJECT DESCRIPTION:
This project rehabilitates the Goddard Space Flight Center Parkway Bridge to extend the life of the structure for another 30 years. The bridge consists of 16-foot wide roadways in each direction separated by a 4-foot wide raised median, with 1.5-foot safety curb on the outside of each roadway. It has a 7-inch reinforced concrete deck covered by a 2-inch bituminous wearing surface. The substructure consists of reinforced concrete stub abutments and solid shaft piers. The bridge deck and abutment walls will be removed and replaced. Approach roadways will be reconstructed. One lane will remain open throughout the construction period.

PROJECT JUSTIFICATION:
The Parkway Bridge, built in 1966, is 35 years old. Recent inspection and testing reveal that time and road salts have caused significant deterioration to the concrete and corrosion to the reinforcing steel. The rate of deterioration increases with time due to the existing road salt contamination. The remaining safe lifetime for the bridge is uncertain, and advancing deterioration could require its immediate closure in the near future. Closure of the bridge would have a significant impact on the area roadway network by curtailing Center access through the gate at the parkway. This would significantly add to the near capacity traffic currently using Greenbelt Road.

IMPACT OF DELAY:
Delay of the project would require increasing yearly investments of maintenance, repair, and inspection funds to maintain the bridge in a safe and operational status. Completion of the project will reduce and largely eliminate any yearly bridge maintenance for the next 10 years.

PROJECT TITLE: Connect Madrid Deep Space Communications Complex (MDSCC) to Commercial Power
COGNIZANT OFFICE: Office of Space Science

INSTALLATION: Jet Propulsion Laboratory
LOCATION: Madrid Deep Space Communication Complex, MDSCC, Madrid, Spain

FY 02 COST ESTIMATE (Thousands of Dollars)	2,800
Project Elements:	
Electrical	2,280
HVAC	60
Power Controls	60
Converter/Transformer Building	300
Modify Existing Heat Recovery System	100

PRIOR YEARS FUNDING:	224
Construction	---
Facility Planning and Design	224

PROJECT DESCRIPTION:
This project will link the MDSCC to commercial electrical power, eliminating single point of failure, reducing near term replacement costs of old diesel engine generators, reducing operation and maintenance costs, and providing emergency backup electrical power. Commercially supplied electrical power will be provided by connecting to the local electrical power grid at the Navalagamella Substation, Spain. The contractor will install a 20KV overhead transmission line. This line will carry the power approximately 16.8 km from the Substation to MDSCC. This effort includes installation of power poles and routing of the transmission line. The new overhead lines will transition to underground lines directly outside the Complex. From there the transmission line will run to a new power converter/ transformer building. The project will modify existing Complex power distribution system to accommodate the automatic transfer from commercial power to Complex-generated power and vice versa. This will be accomplished by the installation of new switchgear and programmable automated controls. The project includes construction of a power converter/transformer building. The building will house the necessary 50/60 HZ frequency converter equipment and hardware, and the step down transformers and switchgear. The new single story high bay prefabricated building will be approximately 400 square meters. Its control room and other equipment areas will be air conditioned to meet equipment requirements. The building will include power distribution, lighting, associated equipment and a 15-ton crane for heavy equipment.

PROJECT JUSTIFICATION:
MDSCC presently operates solely on electrical power generated at the complex. This creates a single point of failure. If operation continues in the same in-house generation mode, the 35-year old diesel engine generators will require replacement beginning in 2003. The switch to commercial power as the prime source of power will relegate the existing generators to a back-up role. This will slow the degradation of the generators, extending their useful lives, and significantly delay the need for their replacement. The emergence of the European Union may result in the imposition of far-reaching, restrictive emission levels. The switch to commercial electrical power at MDSCC will substantially reduce the emission of air pollutants, obviating non-compliance with future environmental regulations.

IMPACT OF DELAY:
Without a commercial power source, electrical power generated at MDSCC would continue to be a single point of failure. The generators would continue to degrade, resulting in higher maintenance costs and replacement of the generators beginning in 2003. Without reducing the emissions of air pollutants MDSCC may fail to comply with European air quality management directives.

PROJECT TITLE: Rehabilitate Aircraft Hangar, Ellington Field
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Johnson Space Center, Ellington Field
LOCATION: Houston, TX

FY 02 COST ESTIMATE (Thousands of Dollars):	3,200
Project Element:	
Construction	3,200

PRIOR YEARS FUNDING	280
Construction	----
Facility Planning and Design	280

PROJECT DESCRIPTION:
This project refurbishes, upgrades and constructs of a two-story, steel-framed addition on the east side of the existing aircraft maintenance hangar E135 at Ellington Field, Houston, TX. It also renovates electrical, heating ventilating and air conditioning equipment, and architectural systems on the west side of the hangar. The existing two-story 8,000 square feet, 5-year-old steel frame, wood construction office wing will be demolished. The new addition will add a gross area of approximately 10,000 square feet. A freight elevator and a new sidewalk will be installed. In order to maintain uninterrupted astronaut/pilot training, either the construction will be phased to assure continuous aircraft operations and maintenance or a temporary facility will be provided during construction to house existing operations, engineering, and maintenance personnel. First story space in the addition will include aircraft maintenance offices used in support of four Shuttle Training Aircraft (STA), administrative aircraft (G159 & G1159) and training aircraft (T-38N), flight crew support spaces, and an aircraft simulator facility. The space will house personnel, computer equipment with networking, a T-38N simulator, aviation test equipment powered by multiple power sources, a technical publications library, a technical documentation production facility, a break room, a physical training facility, and a personnel locker room. Second story space will include aircraft engineering, operations, and information technology offices and a conference room in support of all JSC Aircraft Operations. They will house personnel, computer equipment with networking, computer servers, engineering and drafting equipment, and audio-visual equipment. A built-up roof system will be installed, along with a fall protection system. Fire protection will be provided throughout the facility. Miscellaneous site work includes adding 30 parking spaces for new personnel. The area between the hangar addition and the ramp will be paved with concrete. The project also provides for replacement of the main hangar doors. The renovation work on the west side will include installation of a personnel elevator to provide access to the second floor. HVAC repairs will include replacement of various air-cooled condensing units, air handler units, and boilers. The restrooms will also be refurbished.

PROJECT JUSTIFICATION:
This project is required to replace substandard aircraft operations support facilities and provide additional space for increased operational staff and equipment required for ongoing Shuttle missions and expanding Space Station support functions. This pre-World War II era hangar and its major elements are critically overdue for renovation. The east wing, which is to be demolished, has been damaged by termites. The wood structure is 57 years old, and asbestos is present throughout the facility in walls, floor tile, and insulation. Indoor air quality is poor, evidenced by the mildue stained ceiling tile and HVAC duct. Interior office walls have deteriorated from moisture and mildew. No elevator facilities exist for handicapped personnel. The roof is also in poor condition.

The new space is required to enable/accommodate the following activities. It will host the T-38N Simulator Facility required to provide annual emergency procedures training to astronauts and Aircraft Operation Division (AOD) T-38 pilots. This training is presently conducted at USAF simulator sites that will no longer be available after FY02. No other suitable space is available at

Ellington Field. Off-Site location of the facility would be costly and inefficient. Aircraft engineering civil service and contractor personnel will be relocated to E135 to improve the efficiency of the engineering function, as it will then be located in the area where most field activities occur. That will free up space in Hangar 990 on the north tract of NASA property at Ellington Field to provide research space for the WB-57 and KC-135 flight research programs currently located in the Hangar 990 areas. Existing astronaut and other aircrew locker rooms are fully occupied, and further expansion is required. Specifically, as the number of female astronauts has increased, and with expected further increases, an adequate female locker room is required. The Information Technology function at AOD has expanded from five personnel to 20 with further growth expected. The growth is in part due to the increased reliance on IT for aircraft maintenance, logistics, and operations management and in part due to Aircraft Operations being assigned a lead role and sustaining support of NASA aircraft logistics and maintenance IT development and implementation.

IMPACT OF DELAY:
Delaying this project would impact operational support for both Space Shuttle and Space Station programs in addition to allowing further deterioration of the structure and further extending substandard housing conditions. Delay of this project would result in significant increases in maintenance expenditures to correct these conditions without long term improvement of the substandard conditions. Additionally, the AOD consolidation plans will be delayed, resulting in continued operational inefficiencies and shortfalls.

PROJECT TITLE: Construct Operations Support Building, Pad A Area
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Kennedy Space Center
LOCATION: Brevard County. Merritt Island, FL

FY 02 COST ESTIMATE (Thousands of Dollars):	5,200
Project Element:	
Site Work and Utilities	400
Architectural and Structural	2,300
Mechanical	1,300
Electrical	1,200

PRIOR YEARS FUNDING:	320
Construction	----
Facility Planning and Design	320

PROJECT DESCRIPTION:
This project constructs an Operations Support Building in the Launch Complex 39 Pad A (LC-39A) Area. The facility will be approximately 25,000 square feet, and accommodate approximately 100 technicians and engineers that provide 3-shift processing support. The new facility will be of permanent masonry construction and will have offices, training rooms, and technical documentation storage. Facility systems to be included are heating, ventilation, and air conditioning (HVAC); electrical power; natural gas; water and sewage; fire detection and protection; and paging and area warning systems. The project will also upgrade the existing central utilities and control systems in order to support the new facility. Non-construction funding in the amount of $700,000 will be budgeted to provide for systems furniture, communication systems, computer equipment, and other such outfitting and activation costs.

PROJECT JUSTIFICATION:
This project replaces approximately 40 dilapidated boxcar units (approximately 22,000 square feet) temporarily being used to provide office and operations support space for approximately 100 workers supporting launch pad processing and test and checkout operations. The substandard workspace consists of 50-year-old railroad boxcars that were modified and converted to office use almost 20 years ago. The heavy salt corrosive environment of Florida's Atlantic coast has aggressively attacked and severely corroded these boxcars. The units have greatly exceeded their intended useful service life. Due to significant structural degradation, these boxcars have become maintenance intensive. The severe state of degradation of these units creates a poor workplace environment that adversely affects worker morale and productivity and could potentially affect their safety and health. Trailers, boxcars and other modular buildings at KSC have 24 times more environmental health complaints than comparable permanent facilities at KSC. The extreme state of disrepair of these boxcars is contributing to intensive and unscheduled maintenance having excessive costs; highly inefficient and costly energy consumption; and working environments that barely meet minimum safety and health standards for occupancy. This project is essential to assure a safe and healthy workplace environment for engineers and technicians performing critical operations work affecting timely and reliable launch of the Space Shuttle.

IMPACT OF DELAY:
People performing day-to-day Shuttle support would continue to work in deteriorated, grossly substandard conditions, which adversely affects their morale and productivity, and could potentially affect not only their health and safety, but also the quality of their work for the Shuttle. Operations and maintenance costs and energy consumption would stay excessively high. Productivity would continue at lower levels also because people working on the same activities are not in close proximity to each other.

PROJECT TITLE: Construct Operations Support Building II, LC-39 Area, Phase 2
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Kennedy Space Center
LOCATION: Brevard County, Merritt Island, FL

FY 02 COST ESTIMATE (Thousands of Dollars):	8,400
Project Element:	
Site Work and Utilities	1,000
Architectural and Structural	3,000
Mechanical	2,000
Electrical	2,400

PRIOR YEARS FUNDING:	15,371
Construction	12,971
Facility Planning and Design	2,400

PROJECT DESCRIPTION:

This project provides for the construction of a second Operations Support Building in the LC-39 Vehicle Assembly Building (VAB) area. The complex will be approximately 200,000 square feet and accommodate approximately 1,000 workers. The complex will support operational areas and consist of offices, training rooms, computer rooms, multi-media conference rooms, Mission Conference Center with observation deck, technical libraries, Exchange storage, snack bar, storage, miscellaneous support areas and parking. Facility systems to be included are heating, ventilation, and air conditioning (HVAC); electrical power; natural gas; water; sewage; fire detection and protection; and paging and area warning systems. The project will also upgrade the existing central utilities and control systems in order to support the new complex. This is the second and final increment of this $21.4M project. Non-construction funding in the amount of $14 million will be budgeted to provide for systems furniture, communication systems, computer equipment, and other such outfitting and activation costs.

PROJECT JUSTIFICATION:

A critical need exists to eliminate 280 trailer equivalents of dilapidated substandard housing affecting the safety, morale and welfare of approximately 700 Shuttle processing workers, transient Launch fallback personnel, and personnel who attend training. This project allows consolidation of fragmented programs affecting approximately 300 workers currently scattered across the Center supporting LC-39 operations and Spaceport Technology Center strategies. Additional substandard housing will be eliminated when vacated permanent housing currently being used by the fragmented programs is backfilled. KSC's heavy salt corrosive environment has aggressively attacked and severely corroded the existing 20-year-old portable office trailers and modified railroad boxcars. These units have mold and indoor air quality problems; rotting and termite infested siding and floor substructures; roof and siding that leak; plumbing that does not drain properly; tripping hazards, such as uneven floors and exterior stairs that are wobbly and unstable; and numerous other code violations. Trailers and modular housing have 24 times more environmental health complaints than comparable permanent facilities. This contributes to intensive and unscheduled maintenance having excessive costs; highly inefficient and costly energy consumption; and working environments that barely meet minimum safety and health standards.

IMPACT OF DELAY:

People would continue to work in deteriorated, grossly substandard conditions, which adversely affects morale and productivity, and could potentially affect their health and safety. Maintenance would continue to cost approximately $1.3 million/year more than for conventional permanent facilities and 47% more energy would continue to be consumed. Productivity would continue at lower levels also because people working on the same program are not in close proximity and have to travel greater distances.

PROJECT TITLE: Rehabilitate Atmospheric Sciences Building
COGNIZANT OFFICE: Office of Aerospace Technology

INSTALLATION: Langley Research Center
LOCATION: Hampton, VA

FY 02 COST ESTIMATE (Thousands of Dollars)	2,400
Project Elements:	
Rehab of B1250 & 1ST floor addition:	
Architectural/Civil/Structure	400
Mechanical/Electrical	1,000
Rehab of 2ND & 3RD floors & elevators:	
Architectural/Civil/Structure	500
Mechanical/Electrical	500

PRIOR YEARS FUNDING:	142
Construction	---
Facility Planning and Design	142

PROJECT DESCRIPTION:
This project rehabilitates space in Building 1250 and provides a connection between Building 1250 and 1250A to meet Americans with Disabilities Act (ADA) requirements and space utilization guidelines. This project will modify and repair the existing facility to provide new heating, ventilating, and air-conditioning, electrical equipment, and a new fire suppression system to comply with NASA Safety requirements. The ADA requirements include modifications to existing restroom facilities and a new elevator to allow disabled access. Interior space modifications will be performed to consolidate personnel and to upgrade interior finishes that have surpassed their useful lives. This project will also eliminate at least one of the temporary trailers currently housing personnel.

PROJECT JUSTIFICATION:
Langley currently has substantial workforce housed in substandard space, including Building 1250. The Atmospheric Sciences Division (ASD) anticipates growth of approximately 20 civil servants and a need to accommodate up to 20 visiting scientist at any one time. Laboratory space is urgently needed to accommodate on-going and future flight instrument development, calibration, and checkout. ASD must be able to host visiting scientists from the international pool of universities and other government agencies engaged in the environmental sciences. The building systems are critical to the operations in this facility and affect productivity, operational costs, and code compliance.

IMPACT OF DELAY:
Inadequate facilities would negatively impact ASD's ability to maintain and enhance its world-class leadership in atmospheric remote sensing. People would continue to work in deteriorated substandard facilities, which adversely affects morale and productivity, and could potentially compromise the safety of personnel and property. Operations and maintenance costs and energy consumption would remain excessively high.

PROJECT TITLE: Repairs to Air Conditioning Systems, Various Facilities		INSTALLATION: Langley Research Center	
COGNIZANT OFFICE: Office of Aerospace Technology		LOCATION: Hampton, VA	
FY 02 COST ESTIMATE (Thousands of Dollars)	3,300	PRIOR YEARS FUNDING:	532
Project Elements:		Construction	---
Building 1239C:		Facility Planning and Design	532
Architectural, General, Controls & Electrical	400		
HVAC System	900		
Building 1299:			
Architectural, General, Controls & Electrical	750		
HVAC System	1,100		
Sprinkler System	150		

PROJECT DESCRIPTION:

A new variable air volume (VAV) system comprised of fan powered VAV terminal units with a hot water reheat coil will be utilized in Building 1299 and 1293C. A variable speed air handler with a variable frequency drive will be installed in the mechanical room and utilize chilled water from the existing air-cooled package chillers. A steam to hot water converter will provide hot water to the VAV heating coils. A direct digital control system will allow control and monitoring from Building 1215. The existing absorption chiller will be replaced with a new package unit in Building 1293C. The chiller will use the existing underground water lines. The cost includes piping modifications, new chilled water controls, and new chilled water pump. This project also replaces the control system and installs equipment for dehumidification and pre-treatment of the make-up air. The fume hood industrial exhaust and make-up air will be replaced. This equipment is needed to bring the facility up to standard.

PROJECT JUSTIFICATION:

It has been determined that the status quo is not an option since it cannot provide the required life safety and process requirements needed for the facilities to pursue new work and accomplish their missions. These air conditioning units have reached the end of their useful lives. The equipment is old, unreliable, and incapable of performing under stress, such as maintaining consistent temperature levels in the summertime. The fume hood system deficiencies do not maintain the required exhaust face velocities and make-up air to meet current safety and industrial ventilation requirements and standards. The number of service calls is increasing and maintenance costs are high. The majority of this equipment was identified for replacement by the Facility Assessment Review conducted in 1993.

IMPACT OF DELAY:

People would continue to work in deteriorated substandard facilities, which adversely affects morale and productivity and could compromise the health and safety of personnel. The air conditioning and fume hood systems are critical to the operations in these facilities. Failure of this equipment affects performance and making emergency repairs is expensive and causes significant disruptions.

PROJECT TITLE: Replace Heater 20” Mach 6, CF4 Tunnel
COGNIZANT OFFICE: Office of Aerospace Technology

INSTALLATION: Langley Research Center
LOCATION: Hampton, VA

FY 02 COST ESTIMATE (Thousands of Dollars)	3, 500
Project Elements:	
Heater System	2,300
Building Demolition	100
Building Modifications	400
Building Power Distribution	200
Heater System Installation	350
CF4 Process Modifications	150

PRIOR YEARS FUNDING:	80
Construction	---
Facility Planning and Design	80

PROJECT DESCRIPTION:

The existing storage will be replaced with a reliable, efficient, and environmentally compatible gas-filled heating system. The project involves the procurement of a new combustion heater and the necessary building modifications for installation. The new natural gas combustion heater will have two heat exchangers in series. The first is a combustion-fired unit, which uses combustion products to convectively heat the outside of a coiled tube with CF4 gas flowing on the inside. The second heat exchanger is unfired, but uses the combustion products of the first unit to preheat a second coiled tube, to add thermal capacitance to the system. The proposed heater system is a combination storage/continuous heater. Architectural, civil, structural, electrical and mechanical changes will be made to Building 1275. A second floor will be added to the facility, which will be at least 16 feet high and cover 1,200 square feet. The heater would penetrate through the existing ceiling and extend into the new second floor addition. A separate enclosure will be constructed around the heater, with its own heating and ventilation system. The new second floor addition will be tied in to the existing structure and insulated steel metal siding added.

PROJECT JUSTIFICATION:

The 20-Inch, Mach 6, CF4 Tunnel became operational in 1975 and is a unique National resource that simulates the high density ratio (low ratio of specific heat) aspect of a real gas on aerodynamic performance of earth and planetary vehicles; it is the only heavy gas hypersonic wind tunnel in the Nation and the World. The current tunnel heater system is a storage type and has used either molten lead, molten tin or salt (currently) as the storage media. CF4 is heated via tube bundles immersed in the molten material. Tube failures have occurred releasing lead vapors and contaminants. Internal corrosion of the tubes has produced unacceptable levels of free stream flow particulates. The present salt-bath system lacks versatility, requires long start-up and turn around times, is relatively inefficient, has a restricted temperature range, and cannot maintain a steady reservoir temperature over the required test period. This unique facility is used to certify the aerodynamic performance characteristics of future blunt and moderately blunt aerospace vehicles for advanced space transportation systems programs such as X-33, Advanced Technology Demonstrator and X-34, Small Reusable Booster, and all other Government Agency, industry, and university hypersonic vehicle concepts. The tunnel operates synergistically with four other hypersonic facilities at LaRC to develop flight simulation parameters.

IMPACT OF DELAY:
Delay of this project results in continued risk of heater failure and inefficient system operation. This wastes energy and increases costs. A 6-12 month shutdown caused by failure of the heating system would be unacceptable to the programs involved in four synergistically operated hypersonic facilities.

PROJECT TITLE: Rehabilitate Interior of Office and Laboratory Building	INSTALLATION: Marshall Space Flight Center
COGNIZANT OFFICE: Office of Space Flight	LOCATION: Madison County, Alabama

FY 02 COST ESTIMATE (Thousands of Dollars):	1,800
Project Element:	
Architectural	600
Mechanical	1,000
Electrical	200

PRIOR YEARS FUNDING:	144
Construction	----
Facility Planning and Design	144

PROJECT DESCRIPTION:
This project rehabilitates approximately 17,000 square feet at the east end of A-wing in Building 4487. Through improved architectural, mechanical, and electrical upgrades, the project will convert part of A-wing into functionable computer room and office spaces. The new doors, hardware, carpeting, vinyl composition tile, ceilings and painting will match the existing areas. New raised flooring will be provided in the computer room. The heating, ventilating and air-conditioning (HVAC) work shall consist of the demolition and replacement of the system. Unused high-pressure gas lines will be removed. New drain lines and piping will be provided as required to support the new HVAC systems. The sprinkler system will be upgraded and existing lighting, power, and communication equipment/devices within the project area will be demolished and replaced. Asbestos and lead abatement are also required.

PROJECT JUSTIFICATION:
This project renovates the only portion of the 43-year old Building 4487 that has not been previously renovated. When the other portions of the building were renovated, critical operations within this area prevented renovation work. However, with the removal of large mainframe computer and data systems from this area, it can now be rehabilitated and made available to satisfy an increasing demand for additional office space. As a result of a recent reorganization, approximately 150 additional personnel (40% increase) are to be added to Building 4487, thus critically increasing the need for additional usable office space. Currently, this floor space is relatively unusable because the area has raised flooring in marginal condition, poorly suited HVAC systems, outdated electrical systems, and inadequate fire protection.

IMPACT OF DELAY:
This area was recently cleared of obsolete mainframe computers; is served by outdated HVAC, sprinkler, and electrical systems; and is essentially unusable. If the rehabilitation is not done, this portion of the building would continue to be unusable and unavailable to satisfy increased office space requirements. Personnel would have to be located in a facility remote from their related work groups which would decrease their efficiency and ability to collaborate. Office space would likely have to be leased from a commercial entity off the Center due to limited administrative space on the Center.

PROJECT TITLE: Rehabilitate and Modify Productivity Enhancement Complex
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Marshall Space Flight Center
LOCATION: Madison County, Alabama

FY 02 COST ESTIMATE (Thousands of Dollars):	3,600
Project Element:	
Architectural	1,800
Mechanical	1,100
Electrical	400
Structural	300

PRIOR YEARS FUNDING:	288
Construction	----
Facility Planning and Design	288

PROJECT DESCRIPTION:
This project rehabilitates MSFC's Productivity Enhancement Laboratory (Building 4707). Restoration work includes new insulation; floor surfacing; repair or replacement of door components; repairs and modifications to the heating, ventilating, and air conditioning equipment; relocation of an exhaust system; electrical power distribution and lighting improvements; and interior repairs and painting. A new fire suppression system will be installed to reduce fire hazards in this heavily used development laboratory. Modifications in the Filament Winding area of the building will include raising the height of approximately 5,000 square feet of ceiling to match the height of the adjacent Tape Laying Laboratory area and replacing a 5-ton overhead crane with a 15-ton capacity crane to serve both the filament winding and tape laying laboratories.

PROJECT JUSTIFICATION:
Building 4707 is 44 years old and contains approximately 103,000 square feet of combination high bay and low bay laboratory space. The building is critical to many of NASA's technology development and productivity enhancement initiatives. This facility serves as a model of NASA's new way of doing business in respect to reliability, energy efficiency, and safety. Many of the building's system components have exceeded their design life or are inadequate to satisfy existing requirements or operational improvements. The restoration work will improve reliability, reduce energy costs, and modernize the building to match its function. Improvements to the Filament Winding Facility are required for the fabrication of larger composite structures under improved environmental controls. There is currently no crane in the filament-winding laboratory that can handle large tooling and fabricated structures.

IMPACT OF DELAY:
Delay of this project will cause Building 4707 to continue to deteriorate, increase unplanned disruptions, and prevent safety improvements and optimum use of the facility. With this facility serving as a model of NASA's new way of doing business, reliable operation and energy and safety upgrades are imperative. The Filament Winding Facility will be impacted by restricting the fabrication of large composite structures. Without the new crane, lift trucks and other ground support equipment must be used and this limits the number of fabrication operations that can be performed in the facility. Furthermore, composite structures fabricated in the laboratory are extremely sensitive to contaminants generated by fork trucks and other lift vehicles.

PROJECT TITLE: Rehabilitate Precision Cleaning Facility
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Marshall Space Flight Center
LOCATION: Madison County, Alabama

FY 02 COST ESTIMATE (Thousands of Dollars):	2,100
Project Element:	
Architectural	200
Mechanical	1,500
Electrical	400

PRIOR YEARS FUNDING:	168
Construction	----
Facility Planning and Design	168

PROJECT DESCRIPTION:
This project restores the capabilities of the Precision Cleaning Facility (PCF) located in Building 4705. The scope of this project includes improved environmental control; new cleaning consoles; upgraded air-locks for the clean rooms; heating ventilating, and air-conditioning improvements; new plumbing; hoist modifications; utility gas distribution; and improved lighting. This work will restore the clean room level in the main cleaning area to a cleanliness level of 30K in accordance with Center and Federal standards. In addition, room B124 will be restored to its design cleanliness level of 4K.

PROJECT JUSTIFICATION:
Flight hardware and fixtures fabricated at the center are processed through the PCF to provide a quick turn-around frequently required to meet the various projects' schedule and budget constraints. Projects affected by the facility's ability to meet requirements include the Material Science Research Rack (MSRR), the Quench Module Insert (QMI) and various projects from the Environmental Control and Life Support Systems (ECLSS) organization. The facility has deteriorated to the point where items often require multiple cleanings to achieve the required flight hardware cleanliness level due to the inability of the various components of the PCF to maintain the respective clean room levels of 30K and 4K stated above. This is inefficient in terms of both schedule delays and operational cost increases. Facility systems and subsystems, such as lightning, consoles, pumps, valves and controls, have deteriorated from approximately thirty years of use and chemical exposure. The impact of the current lower cleanliness rating is a high probability of contamination of parts and delayed hardware deliveries.

IMPACT OF DELAY:
Without repair or replacement work, deterioration of the PCF in Building 4705 will continue, maintenance costs will increase and the facility will no longer be able to support the required parameters of the projects. Further neglect will result in more frequent schedule delays for flight hardware and increased costs for precision cleaning due to the multiple cleanings required. Ultimately, the PCF will likely be forced to shut down and items will have to be shipped to other cleaning facilities with the associated increases in transportation risks, costs and schedule delays.

PROJECT TITLE: Repair and Upgrade Substations 31, 32, and 33
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Michoud Assembly Facility
LOCATION: New Orleans, Orleans Parish, LA

FY 02 COST ESTIMATE (Thousands of Dollars):	2,400
Project Element:	
Site Preparation and Demolition	80
Switchgear and Breakers	735
Motor Control Centers, Switchboards, and FDR Sections	300
Wires and Cable Terminations	700
Transformers & High Voltage Switches	400
Miscellaneous Fittings and Components	185

PRIOR YEARS FUNDING:	192
Construction	----
Facility Planning and Design	192

PROJECT DESCRIPTION:

This project replaces three substations (#31, #32, and #33) located on the roof of Bldg. 350. Each substation will be upgraded to a 1500 kVA double-ended configuration. The primary switches, transformers, switchgears, including main and tie breakers will be replaced, and Programmable Logic Control (PLC) interfaces for the control of emergency power transfer of each substation will be provided. The high voltage 13.8 kV sectionalized switches will be replaced, as well as associated feeders #18 and #39. Associated PLC controlled emergency power transfer and energy management monitoring capabilities will also be replaced. The new system will be compatible with the existing 13.8kV feeders.

PROJECT JUSTIFICATION:

The manufacturer of the original sectionalized switches is out of business, and parts are no longer available. Failure of these switches impacts the entire power distribution of Building 350. The switchgear and breakers have obsolete parts requiring replacement components to be custom built to rigid specifications. Transformers are PCB-contaminated, posing a potential environmental impact. Substation loads are nearing, and in some cases exceeding, the capacity of the transformers. The substations are located on Building 350 roof and provide power to Building 350 for general HVAC, United States Department of Agriculture (USDA) data hardware, UPS for Consolidated Computer Operation Center, LAN File Server Room, telecommunications, NASA offices, emergency storm drainage pumps and sewer lift station. Building 350 provides space to NASA, Defense Contract Audit Agency, Defense Contract Management Agency, USDA, National Finance Center, Lockheed Martin and other agencies. The substations and their associated equipment were installed in 1964, and the majority of the systems are over 35 years old. Expected substation 31 loads exceed the transformer capacity. Substation 33 is reaching the limit of its capacity to reliably meet present conditions. The transformers have been refilled five times since 1988 attempting to reduce PCB concentrations. Periodic testing show the transformers continue to exceed maximum allowable PCB level of 50 ppm, forcing us to refill them every two years.

IMPACT OF DELAY:

The Substations are vital to continuation of 24 hours per day operations of various departments located in Building 350. If the systems are not replaced, maintenance costs and delays would continue to increase. Failure of a main breakers would stop work activities of building occupants, and critical computer operations equipment would lose power. Continued use of antiquated and obsolete equipment risks severe injury to maintenance personnel from electrical arcing, and continues the risk of PCB leakage.

PROJECT TITLE: Replace Roof, External Tank Manufacturing Building, Phase 1
COGNIZANT OFFICE: Office of Space Flight

INSTALLATION: Michoud Assembly Facility
LOCATION: New Orleans, Orleans Parish, LA

FY 02 COST ESTIMATE (Thousands of Dollars):	12,000
Project Element:	
Site Preparation and Demolition	2,300
Precast Concrete Panels/Moisture Control	800
Lightweight Purlins/Fasteners	300
Roof Deck Insulation/Foamglass	2,000
Built-up Roofing	1,900
Reflective Coating	1,200
Membrane Roofing	2,600
Miscellaneous/Equipment Rental	600
Piping/Lightning Protection	300

PRIOR YEARS FUNDING:	360
Construction	----
Facility Planning and Design	360

PROJECT DESCRIPTION:
This project is the first of two phases to replace Building 103 roofing system (1,679,200 square feet) and roof drainage piping. Components of the roofing system to be replaced include deteriorated timber purlins (replaced using light gauge steel); damaged concrete planks; base sheet; 4-ply built-up felt system; glaze coat and reflective topcoat. Repairing the roof drainage piping involves removing/replacing downspouts, as well as using lining material to repair a portion of the downspouts that are inaccessible. The horizontal run-outs that connect the downspouts to roof drains will also be replaced. Cast iron/galvanized pipe will be replaced with PVC or fiberglass pipe to ensure reliability. Funds in the amount of $12M will be budgeted in FY03 to complete this project.

PROJECT JUSTIFICATION:
Building 103, the “External Tank Manufacturing Building,” was constructed in 1943. It is primarily used for Shuttle External Tank assembly (chemical cleaning, component cleaning, component painting, harness fabrication, heat treating, machining, riveting, tube fabrication, and welding) and new business (X33, RLV, and NCAM). Building 103 has a roof area of approximately 40 acres. An in-house study completed in September 1998 found the roof to be deteriorated beyond the capabilities of a major maintenance restoration project. Roof leaks that can cause damage to production equipment and flight hardware and injury to personnel if not addressed are occuring throughout various areas of the building. Surface deficiencies and a high moisture content were also found.

Building 103 also has approximately 100 downspouts for draining rainwater from the roof. The fire water system and air handling units also drain into the downspouts. The downspouts penetrate the floor slab and tie into the main storm drainage pipes that run to the Borrow Canal. During severe rainfall, storm water is forced out of faulty joints and runs out onto the factory floor and utility trenches. This creates hazardous conditions to personnel. Temporary repairs are made on damaged downspouts to stop leaks. Approximately 40% of the downspouts are not accessible because electrical panels or other equipment block access to them. Horizontal run-outs connect the downspouts to the roof drains. There are three different types of run-outs: cast iron, galvanized, and fiberglass. The majority of leaks in Building 103 stem from the horizontal run-outs. Cracks form on the top of the cast iron pipe making them unnoticeable until rainwater leaks. Holes form around the galvanized pipe and allow rain to infiltrate the building. Several repairs are made on these run-outs during periods of severe weather.

IMPACT OF DELAY:
Failure to replace roofing system could result in risk to personnel safety, and potentially extensive and costly damage to flight hardware and production equipment. As the downspouts, horizontal run-outs and 4-ply roof continue to deteriorate, more leaks will occur.

PROJECT TITLE: Minor Revitalization and Construction of Facilities, Not in Excess of $1.5 million Per Project
COGNIZANT OFFICE: Office of Management Systems LOCATION: Various

	Mission Support	Human Space Flight
FY 02 COST ESTIMATE (Thousands of Dollars)	86,700	6,600
Location:		
Ames Research Center	10,300	
Dryden Flight Research Center	4,200	
Glenn Research Center	10,100	
Goddard Space Flight Center	13,100	
Jet Propulsion Laboratory	11,700	
Johnson Space Center	9,900	
Kennedy Space Center	4,900	6,600
Langley Research Center	10,000	
Marshall Space Flight Center	3,200	
Stennis Space Center	9,300	

PROGRAM DESCRIPTION:
Proposed projects for FY 2002 are identified under "MINOR PROJECT COST ESTIMATE". They include Mission Support projects totaling $88.1 million for components of the basic infrastructure and institutional facilities, and $5.9 million to accomplish specific Human Space Flight projects. The $5.9 million is included in the appropriate budget line items of the Human Space Flight appropriation. The cost estimates are shown here to provide a complete picture of NASA's budget requirement for facilities.

These resources provide for revitalization and construction of facilities at NASA field installations and Government-owned industrial plants supporting NASA activities. The request includes facility revitalization and construction needs for FY 2002 that are greater than $500 thousand but not in excess of $1.5 million per project. Revitalization projects provide for the repair, modernization, and/or upgrade of facilities and collateral equipment. Repair and modernization projects restore facilities and components thereof, including collateral equipment, to a condition substantially equivalent to their originally intended and designed capability. Repair and modernization work includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. It also includes major preventive measures that are normally accomplished on a cyclic schedule, and those quickly needed out of cycle based on adverse condition information revealed during predictive testing and inspection efforts. Upgrade projects may include not only some restoration of current functional capability, but also enhancement of the condition of a facility so that it can more effectively accomplish its designated purpose or increase its functional capability. Occasionally minor facility construction projects will be required to provide for either the construction of small new facilities or additions to existing facilities. The facilities being revitalized or constructed in this program are expected to remain active in the long term and are consistent with current and anticipated Agency roles and missions. Annual funding will be required for continuing minor revitalization and construction needs.

This program includes revitalization and construction projects estimated to cost more than $500 thousand per project. Projects $500 thousand and less in magnitude are normally accomplished by routine day-to-day facility maintenance and repair activities provided for in Research Operations Support and direct program operating budgets. Projects estimated to cost more than $1.5 million are included as separate discrete projects in the budget request.

PROGRAM JUSTIFICATION:
NASA is experiencing "block obsolescence" because 90% of the agency's facilities have been in use for over 25 years. Repair costs for mechanical and electrical systems in a typical building are almost three times higher after system operations exceed 15-20 years than they are during the initial years. Many electrical and mechanical components reach the end of their serviceable or economic life at the 20-year point and should be replaced. Continued piecemeal repair of these components is more costly in the long run than replacement at the end of the economic life of the original components.

The NASA physical plant has a capital investment of over $6 billion with a current replacement value of more than $20 billion. A continuing program of revitalization of these facilities is required to accomplish the following:

a. Protect the capital investment in these facilities by minimizing the cumulative effects of wear and deterioration.
b. Ensure that these facilities are continuously available and that they operate at peak efficiency.
c. Improve the capabilities and usefulness of these facilities and thereby mitigate the effects of obsolescence.
d. Provide a better and safer environment for all personnel.
e. Reduce current operating costs and avoid significantly greater future repair costs.

New construction will primarily replace substandard facilities in cases where it is more economical to demolish and rebuild than it is to restore. Included are projects that replace old and dilapidated railroad box cars, trailers, and other modular facilities that do not meet current occupational health and safety standards, and which no longer satisfy user functional requirements. In selected cases, additional square footage may be built when there are compelling reasons to support specialized requirements of a nature that cannot be provided for using existing facilities. Included in this latter category are technical, programmatic, and institutional projects that are essential to the accomplishment of an installation's mission objectives.

MINOR PROJECT COST ESTIMATE (Thousands of Dollars):
The projects that comprise this request are of the highest priority based on relative urgency and expected return on investment. Deferral of this mission-essential work would adversely impact the availability of critical facilities and program schedules. The titles of the projects are designed to identify the primary intent of each project and may not always capture the entire scope or description of each project. Also, during the year, some rearrangement of priorities may be necessary which may force a change in some of the items to be accomplished. Any such changes, however, will be accomplished within total the resources available.

HUMAN SPACE FLIGHT	6,600
A. Kennedy Space Center (KSC)	6,600
1. Restore Low Voltage Power System, LC-39A, Phase II (Space Shuttle)	1,500
2. Refurbish Rotating Service Structure Drive Trucks, LC-39A (Space Shuttle)	1,200
3. Refurbish Rotating Service Structure Drive Trucks, LC-39B (Space Shuttle)	1,200
4. Modernize Launch Vehicle Data Center, Vandenberg Launch Site (ELV)	1,200
5. Upgrade Mobile Service Tower and Pad Lighting, Vandenberg Launch Site SLC-2 (ELV)	750
6. Repair and Modernize HVAC, Payload Hazardous Servicing Facility, Phase I (Payload Carriers)	750
MISSION SUPPORT	86,700
A. Ames Research Center (ARC)	10,300
1. Rehabilitate and Modify 20MW Power Supply, Phase III	825
2. Rehabilitate Arc Jet Water Cooling System, Phase II (N234)	1,450
3. Seismic and Safety Modifications, Phase II (19)	1,450
4. Replace First Floor HVAC Systems (N233)	700
5. Repair North and South Central Steam Vacuum System Plenum Shells	825
6. Fire Suppression/Alarm and Seismic Modifications (N241)	1,050
7. Repair Roofing and HVAC Systems (N236, Wings A &B)	1,150
8. Modify Developmental Arc Jet Facility for 5MW Arc Jet Heater (N234)	1,450
9. Construct Perimeter Security Fence	1,400
B. Dryden Flight Research Center (DFRC)	4,200
1. Repair Infrastructure, Phase II (4800)	1,400
2. Rehabilitate and Modify Electrical Distribution System (4840)	1,350
3. Refurbish Area A Ramp	1,450

C.	Glenn Research Center (GRC)	10,100
	1. Repair Natural Gas System, Phase III	1,200
	2. Install 450 PSIG Heater, Propulsion Systems Laboratory (125)	900
	3. Rehabilitate and Modify Engineering Building, Plum Brook Station [PBS] (7141)	1,200
	4. Install Cryopumping System, Space Power Facility (1411), PBS	1,000
	5. Modifications to Fire Alarm & Sprinkler Systems, Engine Research Building, Phase I (5&23)	950
	6. Rehabilitate Mechanical and Electrical Systems, High Temperature Composites Laboratory (51)	750
	7. Repair High Voltage Switchgear, Central Air and Equipment Building (64)	900
	8. Mercury Clean-Up, Electric Propulsion Research Building (16)	900
	9. Modifications to Alternate Propellant System, 10x10 Supersonic Wind Tunnel (85)	900
	10. Construct Facility for Fuel Cell Testing (333)	1,400
D.	Goddard Space Flight Center (GSFC)	13,100
	1. Replace HVAC Equipment for Clean Rooms (7)	1,000
	2. Repair Roofs, Various Buildings	800
	3. Repair of Storm Drain System, Phase VI Wallops Flight Facility [WFF]	950
	4. Rehabilitate Communication Ductbank System, Phase II, WFF	750
	5. Modifications to Multi-Payload Processing Facility, Phase III, WFF	1,300
	6. Rehabilitation of Building F-160, WFF	800
	7. Rehabilitation of Building F-10, North Wing, WFF	600
	8. Rehabilitation of Island Roads, WFF	700
	9. Repair Low Voltage Electrical Systems, Various Buildings	600
	10. Construct Balloon Launch Pad, Ft Sumner, NM, WFF	900
	11. Repair High Voltage Electrical Systems, Various Buildings	800
	12. Repair Fire Protection & Domestic Water Systems, Various Buildings	650
	13. Modifications to E Complex, Phase I, WFF	1,450
	14. Construct Addition to Visitor's Information Center, WFF	600
	15. Renovation of Management Education Center Dormitory, WFF	1,200

E.	Jet Propulsion Laboratory (JPL)	11,700
1.	Upgrade Hydraulic Drive, 26M Antenna, Canberra, Australia	900
2.	Modify Compact Antenna Measurement Range Building (212)	1,450
3.	Construct Addition to Atmospheric Remote Sensing Laboratory (245)	650
4.	Construct Addition to Microwave Front End Test Facility (238)	550
5.	Construct Antenna Support Building, Madrid, Spain	600
6.	Upgrade Gaseous Nitrogen Supply, Phase II	550
7.	Modify Building 233 for Micro-Electro-Mechanical Systems	1,150
8.	Refurbish/Upgrade Advanced Propulsion Test Facility (148)	600
9.	Construct Extension to Frequency Standards Laboratory (298)	1,450
10.	Construct Central Chilled Water System, Apollo Site, Goldstone	650
11.	Refurbish Cafeteria (167)	1,450
12.	Expansion of Multi-Media Facilities (186)	950
13.	Repair Pavements, Various Roads	750
F.	Johnson Space Center (JSC)	9,900
1.	Refurbish Elevated Storage Tank and Miscellaneous Support Buildings	800
2.	Replace Air Handlers, Communications and Tracking Development Laboratory (44)	1,000
3.	Rehabilitate and Modify Life Sciences Laboratory Building, Phase I (37)	900
4.	Repair Air Handlers, Project Management Building, Phase I (1)	1,100
5.	Replace Roofs, Photographic Laboratory and Bioengineering Test Support Facility (8, 36)	1,200
6.	Replace Loggia Ledge Coverings, Phase II, Various Buildings	1,500
7.	Replace Roofs, Logistics Support Buildings (419, 421)	1,000
8.	Replace Air Conditioning Systems, Various Buildings (36, 49, 354)	600
9.	Replace Air Handlers, Mission Simulation Development Facility (35)	700
10.	Repair and Upgrade Building Systems, White Sands Test Facility (300 Area)	1,100
G.	Kennedy Space Center (KSC)	4,900
1.	Safety Modifications to Pad A Hinge Column Crossover	500
2.	Replace 15-KV Feeder 518/612, C5 to SS-900	1,000
3.	Revitalize Secondary Power Systems, Vehicle Assembly Facility, Phase 2	900
4.	Construct Replacement Air Traffic Control Tower, Shuttle Landing Facility	1,500
5.	Construct Replacement Perimeter Security Gates	1,000

H.	Langley Research Center (LaRC)	10,000
	1. Upgrade Drive Control System, Transonic Dynamics Tunnel (648)	1,425
	2. Replace Heat Exchanger, 31-inch Mach 10 Tunnel (1251A)	1,400
	3. Modifications to 12-foot Low Speed Tunnel Main Drive (644)	700
	4. Replace Anechoic Absorber Material, Low Frequency Antenna Chamber (1299)	1,425
	5. Rehabilitate 2x3 Low Speed Boundary Layer Tunnel (1247H)	800
	6. Construct Second Floor for Work Force Consolidation (1216)	1,425
	7. Rehabilitate Central Computing Complex (1268)	1,425
	8. Construct Second Floor and Addition for Work Force Consolidation (1195)	1,400
I.	Marshall Space Flight Center (MSFC)	3,200
	1. Repair and Modify Process Water System, Michoud Assembly Facility [MAF] (117)	1,000
	2. Replace Roof, Component Ablator Facility, MAF (318)	800
	3. Replace Emergency Storm Drainage Pumps, MAF (106, 143, 304)	1,400
J.	Stennis Space Center (SSC)	9,300
	1. Rehabilitate Water Systems, Engine Test Complex	1,400
	2. Repair and Modernize HVAC, Environmental Laboratory, Phase II (1105)	1,100
	3. Increase Capacity and Expand GH2/GN2 High Pressure Distribution System, Phase II	1,300
	4. Modify Propulsion Test and Support Facilities, E Complex, Phase II	800
	5. Repair and Modernize Fire Alarm Systems, Various Facilities, Phase III	700
	6. Repairs to Structural and Mechanical Systems, B-2 Test Stand, Phase II	600
	7. Repair and Modernize Secondary Power Systems, Various Facilities, Phase III	900
	8. Repairs to High Pressure Piping System, Engine Test Complex	900
	9. Repair and Modernize HVAC, Test Complex	700
	10. Repair and Modernize 13.8KV Underground Cable	900

PROJECT TITLE: Facility Planning and Design
COGNIZANT OFFICE: Office of Management Systems LOCATION: Various

FY 02 COST ESTIMATE (Thousands of Dollars)	15,100
Project Elements:	
Master Planning	400
Sustaining Engineering Support	1,000
Project Planning and Design Activities	13,700

These funds are required to provide for advance planning and design activities; special engineering studies; facility engineering research; preliminary engineering efforts required to initiate design-build projects; preparation of final designs, construction plans, specifications, and associated cost estimates; and participation in facilities-related professional engineering associations and organizations as follows:

A. Master Planning 400

The NASA field installation master plans need to be periodically updated. The master plans are essential as reference documents for land use planning, identification of physical relationships of facilities, and proper orientation and arrangement of facilities. The updates reflect as-built condition of facilities and utility systems with emphasis on changes caused by recent facility construction and modifications.

B. Sustaining Engineering Support 1,000

Provisions for facility studies and specific engineering support continue in importance as evidenced in recent years. These efforts are important due to changing trends in construction equipment, materials, and fuels; the operation and maintenance costs for the physical plant; and energy conservation and efficiency. The following items are included:

1. Value Engineering, and Design and Construction Management Studies

Provides for critically important studies to improve the quality and cost effectiveness of NASA's facility components and construction practices, and to ensure that developing technology and industry best practices are incorporated into the agency's construction program. Also provides services necessary to predict and validate facility costs to aid in resources planning and studies to assess design and construction functional management.

2. Facility Operation and Maintenance Studies

Provides for studies and engineering support, where not otherwise provided for, at NASA field installations relative to functional management of maintenance, automated maintenance management systems, and facilities condition assessments. Included in this activity are field surveys to be conducted at selected NASA field installations to evaluate the effectiveness and efficiency of the operations and maintenance management activities, and to identify possible improvements in productivity.

3. Facilities Utilization Analyses

Provides for the analyses of agency-wide facilities utilization data covering (1) office and other types of building space; (2) designated major technical facilities; and (3) special studies comparing the utilization of technical facilities which are similar in type or capability, such as wind tunnels. Such analyses provide for (1) insights into and development of better methods of identifying underutilized facilities; (2) improved techniques to quantify level of facilities use; (3) actions to improve facilities utilization; and (4) recommendations regarding consolidation/closure of Agency facilities.

4. Facilities Management Systems

Provides for continued engineering support for the technical updating of NASA's master text construction specifications to reflect the use of new materials, state-of-the-art construction techniques and current references to building codes and safety standards. Also provides engineering support for the Major Facilities Inventory, the Real Property Database and the Facilities Utilization Database systems.

5. Capital Leveraging Research Activities

Provides for modest participation in facilities related professional engineering associations, institutes, and organizations established to bring together major facility owners, contractors, and academia in proven research and study efforts to improve the quality and cost effectiveness of facilities engineering management practices for member organizations. Such organizations include, but are not limited to the Federal Facilities Council of the National Research Council, Construction Industry Institute, Fully Integrated and Automated Technology Consortium, and National Institute of Building Sciences. This also provides for independent research activities to address facility problems unique to NASA.

C. <u>Project Planning and Design Activities</u> <u>13,700</u>

These resources provide for project planning and design activities associated with Mission Support construction projects. Project planning and design activities for construction projects required to conduct specific Human Space Flight or Science, Aeronautics, and Technology programs or projects are included in the appropriate budget line item.

1. Preliminary Engineering (700)

This estimate provides for preparation of Preliminary Engineering Reports (PERs), investigations, project studies and other pre-project planning activities related to proposed facility projects. Construction of Facilities programs. These reports are required to permit the early and timely development of the most suitable project to meet the stated programmatic and functional needs. Reports provide basic data, cost estimates and schedules relating to future budgetary proposals.

2. Related Special Engineering Support (1,500)

This estimate provides for investigations and project studies related to proposed facility projects to be included in the subsequent Construction of Facilities programs. Such studies involve documentation and validation of 'as-built' conditions, survey/study of present condition of such items as roofing and cooling towers, utility plant condition and operational modes, and other similar field investigations and studies. These studies are required to support long term project development strategies, and project specific designs, cost estimates, and schedules.

3. Design	(11,500)

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of construction projects. Also provides technical and engineering support analyses, designs, and reviews required to verify, confirm and ensure suitability of construction designs within the project cost estimates. This work is associated with construction proposed for the FY 2004 program and with changes to projects proposed for the FY 2003 program. The goal is to obtain better facilities on line earlier at a lower cost.

Total Facility Planning and Design	15,100

PROJECT TITLE: Environmental Compliance and Restoration Program
COGNIZANT OFFICE: Office of Management Systems, Environmental Management Division LOCATION: Various Locations

FY 02 Cost Estimate (Thousands of Dollars)	57,000
Location:	
Ames Research Center	1,500
Dryden Flight Research Center	600
Glenn Research Center	16,930
Goddard Space Flight Center	325
Jet Propulsion Laboratory	7,735
Johnson Space Center	2,220
Kennedy Space Center	7,460
Langley Research Center	1,130
Marshall Space Flight Center	5,900
Michoud Assembly Facility	1,750
Stennis Space Center	870
Wallops Flight Facility	280
White Sands Test Flight Facility	6,400
Headquarters	3,900

PROGRAM DESCRIPTION:
The Program provides for environmental activities necessary for compliance with environmental requirements including environmental program initiatives. Proposed environmental activities for FY 2002 are identified below under "ENVIRONMENTAL ACTIVITIES COST ESTIMATE" title. The Program includes activities necessary for NASA to comply with environmental statutory and regulatory requirements and standards, orders, regulatory and cooperative agreements, and support of environmental program initiatives. The Program focuses our efforts in the principal areas of environmental compliance, remediation, conservation, pollution prevention and closures. Within this framework, compliance with environmental requirements is performed, while simultaneously remediating previously contaminated sites, performing environmental closures, and promoting the identification of pollution prevention and conservation activities. The resources authorized and appropriated pursuant to this Program may not be applied to other activities. Program activities include projects, studies, assessments, investigations, plans, designs, related engineering, program support, and sampling, monitoring, and operation of remedial treatment processes and sites as part of the remediation and cleanup measures. These activities will be performed at NASA installations, NASA-owned industrial plants supporting NASA activities, and other current or former NASA sites where NASA operations have contributed to environmental problems and NASA is obligated to contribute to cleanup costs. In addition, these resources will be used to provide for activities including regulatory agency oversight costs, to acquire land if necessary to implement environmental compliance and restoration measures, and to perform studies, assessments and other activities in support of functional leadership initiatives related to the environmental program.

PROGRAM JUSTIFICATION:

The Program represents this year's request on a phased approach in relation to the total Agency requirements for environmental remediation measures that must be implemented within the next several years, as well as for needed requirements for other environmental compliance measures and initiatives. The Program includes activities necessary for compliance with environmental statutory and regulatory requirements and standards, orders, regulatory and cooperative agreements, and support of environmental program initiatives. Based on relative urgency and potential health hazards and safety, these activities are the highest priority requirements currently planned for accomplishment in FY 2002. Deferral of these necessary compliance and remedial measures would preclude NASA from complying with environmental requirements and regulatory agreements, and jeopardize NASA operations. As studies, assessments, investigations, plans, regulatory approvals, and designs progress and as new discoveries or regulatory requirements change, it is expected that priorities may change and revisions to these activities may be necessary.

The broad environmental categories summarizing the efforts proposed to be undertaken with the identified estimated costs are listed below. Remediation activities include one or more phases of a site cleanup program from site identification to final closeout, including but not limited to site assessments, site investigations, interim cleanup actions, testing and evaluation, remedial treatment systems and processes operation, sampling and monitoring, and other activities associated with CERCLA/RCRA cleanup requirements.

a. Environmental Remediation Activities and Initiatives --- Remediation (e.g. CERCLA, RCRA) ....$ 33,725

b. Other Environmental Compliance Requirements and Initiatives ---
Compliance, Restoration, Prevention, Closures (e.g. CAA, CWA, RCRA, ESA, AEA, PPA) ....$ 23,275

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
RCRA = Resource Conservation and Recovery Act
CAA = Clean Air Act
CWA = Clean Water Act
ESA = Endangered Species Act
AEA = Atomic Energy Act
PPA = Pollution Prevention Act

ENVIRONMENTAL ACTIVITIES COST ESTIMATE (Thousands of Dollars):
The activities that comprise this request are as listed below by location.

A. Ames Research Center (ARC)	1,000
1. Remediation of Area of Investigation 11	500
2. Remediation of Area of Investigation 4	500
B. Dryden Flight Research Center (DFRC)	600
1. Remediation of Soil/Groundwater Contamination	600
C. Glenn Research Center (GRC)	16,700
1. Remediation of Contaminated Areas	700
2. Plum Brook Reactor Decommissioning (detailed description provided below)	16,000
D. Goddard Space Flight Center (GSFC)	200
1. Remediation of Landfills (4)	200
E. Jet Propulsion Laboratory (JPL)	7,615
1. Cleanup of Arroyo Seco Groundwater Contamination	6,915
2. Pasadena and Lincoln Avenue Agreements	700
F. Johnson Space Center (JSC)	1,600
1. Pretreatment of Hazardous Waste System Modification (8)	650
2. Closure of Impoundment and Relocate Sewer, Phase 2	550
3. Plating Shop Pretreatment	400
G. Kennedy Space Center (KSC)	2,300
1. Remediation at Fuel Storage Area #1 (CCAS)	800
2. Various Interim Measures, Various Locations (KSC and CCAS)	1,500

H. Langley Research Center (LaRC)	1,000
1. Upgrade of Heating Plant Concrete Tanks	1,000
I. Marshall Space Flight Center (MSFC)	5,310
1. CERCLA Investigation and Cleanup	4,500
2. RCRA Investigation and Cleanup, Santa Susana Field Laboratory	200
3. Groundwater Investigation and Cleanup, Santa Susana Field Laboratory	610
J. Michoud Assembly Facility (MAF)	1,700
1. Remediation Activities, Various Locations	1,700
K. White Sands Test Facility (WSTF)	6,400
1. Groundwater Contamination Assessment and Remediation	6,400
L. Studies, Assessments, and Investigations; Plans; Designs; Sampling, Monitoring and Operation of Remedial Treatment Systems; Related Engineering and Program Support, Various Locations	12,575
Total Environmental Compliance and Restoration Program	57,000

PROJECT TITLE: Plum Brook Reactor Decommissioning
COGNIZANT OFFICE: Office of Management Systems

INSTALLATION: Glenn Research Center
LOCATION: Plum Brook Station Sandusky, OH

FY 02 COST ESTIMATE (Thousands of Dollars):	16,000
Project Elements:	
Mobilization	1,000
Decommissioning, Demolition, Waste Management	8,000
Environmental, Safety & Health Support, Construction & Project Management, Community Relations, Institutional & Technical Support	7,000

PRIOR YEARS FUNDING*:	13,018
**FY 1998 –FY 2001:*	
Pre-decommissioning work	8,800
Plans, studies and samplings	4,218

PROJECT DESCRIPTION:
This project decommissions and demolishes the nuclear test reactor located in Plum Brook Station in Sandusky, Ohio. The reactor has been in standby mode since 1975. Work towards decommissioning began with the Nuclear Regulatory Commission required Decommissioning Plan in 1999. The decommissioning work will be performed in a phased approach and is expected to end in 2006 or 2007. The actual end date will depend on what is found as the decommissioning and demolition work evolves. In 2002, the primary work to be performed will be reactor building decontamination, removal of the reactor vessel internals, and waste management. Other activities include community relations; mobilization; environmental, safety and health support; and asbestos abatement. The current cost estimate to complete the decommissioning work, by 2006/2007, ranges from $150 to $175 million.

PROJECT JUSTIFICATION:
The Nuclear Regulatory Commission (NRC) is the regulatory agency requiring NASA to decommission the Plum Brook Reactor. NRC issues licenses for nuclear reactors. In 1998, the NRC, through the Plum Brook Station reactor license, directed NASA to decommission the reactor by 2007. The reactor has been without nuclear fuel and in mothball status since 1975. Decommissioning activities are required by NRC regulations under 10 CFR 20.82 (b) and 10 CFR 50.

IMPACT OF DELAY:
Delay of the project would cause NASA to be in violation of Nuclear Regulatory Commission (NRC) requirements. The NRC has notified the American public of the decommissioning, and the Ohio delegation and Sandusky Ohio community have been directly contacted with the projects overarching goals, objectives, and target end dates. Delay of this project would prevent NASA from honoring these commitments and jeopardize NASA's credibility with the community.

INSPECTOR GENERAL

FISCAL YEAR 2002 ESTIMATES

BUDGET SUMMARY

OFFICE OF INSPECTOR GENERAL

SUMMARY OF RESOURCE REQUIREMENTS

	FY 2000 OPLAN REVISED	FY 2001 OPLAN REVISED	FY 2002 PRES BUDGET
		(Thousands of Dollars)	
Personnel & related costs	18,686	21,123	21,750
Travel	598	1,098	1,200
Operation of installation	716	728	750
Total	20,000	22,949	23,700
Distribution of Program Amount by Installation			
Headquarters	20,000	22,949	23,700
Total	20,000	22,949	23,700

INTRODUCTION

The NASA Office of Inspector General (OIG) budget request of $23.7 million for FY 2002 is based primarily on 213 Full-Time Equivalents (FTEs). The personnel and related cost of the 213 FTEs represents approximately 92 percent of the total OIG budget request. At the requested level, the OIG will: (1) maintain a balanced inspection and audit program, including providing technical assistance and oversight of the audit of the Agency's financial statements as required by the Chief Financial Officers (CFO) Act; (2) concentrate investigative resources on procurement fraud and computer crime matters including emphasis on prevention initiatives; (3) work cooperatively with management by conducting inspections, assessments and reviews of issues identified by the OIG as well as those that are of concern to Agency management; and (4) deploy audit and inspections staff to timely provide feedback on NASA's re-engineering and streamlining initiatives. This budget level recognizes the fiscal constraints facing the Agency and the need for the OIG to provide quality products and services that are timely and meet our customers' needs. In light of budget constraints, the Inspector General continues streamlining activities to increase the mission capability of the OIG staff. Initiatives include continued conversion of administrative overhead positions to program assistants and analysts responsible for assisting on direct mission activities of the audit, investigative, and inspection missions; and matrixing existing personnel and management analyst positions to support direct mission activities. In addition, the OIG continues to streamline and simplify communications and reporting channels, and improve computer and telecommunications capacities to further increase staff capabilities.

As NASA continues to downsize, establish new priorities, and modify its programs and operations within proposed budget constraints, efforts will continue within the OIG to concentrate staff resources on those programs and operations identified as the most critical and vulnerable to crime, fraud and abuse. Throughout this process, the OIG continues its cooperation with NASA management while assuring that the OIG's statutory independence is maintained. The OIG will continue to set priorities based on funding levels, program needs, Congressional and Administration concerns, and the results of OIG research and findings.

The OIG's missions include conducting independent audits, investigating, and inspecting/assessing/reviewing NASA's programs and operations while working as cooperatively as feasible with NASA’s management and program managers. Audits will be prioritized and selected to evaluate programmatic, operational and financial management concerns, information technology systems and operations, and internal control vulnerabilities. The investigations program, with its computer crimes capability, will continue to place greater emphasis on the investigation of computer intrusions and frauds in which the computer was used as an instrument of the crime. The remaining investigation's program will focus on complex procurement and other fraud matters including fraud against the Government by contractor and Government employees, product substitution, bribery, kickbacks, and other procurement irregularities. Each investigative matter will be approached on a programmatic, priority basis to identify preventive initiatives. Inspections, assessments, and reviews will be conducted which support: management's interests and concerns in achieving NASA's programmatic objectives more efficiently and effectively; issues of Congressional concern; matters of high Agency vulnerability; and administrative inquiries related to unethical and improper conduct, waste and mismanagement.

OBJECTIVES AND STATUS

This request represents the OIG resources (FTE’s) needed at NASA Headquarters and field offices to fulfill the OIG mission. Recognizing that every identified audit, investigations, inspections, assessments, and other workload reviews significantly exceed the available resources, continuous adjustments of priorities will be necessary to ensure: a balanced coverage of NASA's programs and operations is maintained; all critical and sensitive matters are promptly evaluated and investigated; and all OIG customers receive timely, accurate, and complete responses.

The OIG uses a formal, comprehensive process to identify, review, prioritize, and select the audits, inspections, evaluations, and reviews that are to be performed. The OIG assignments are derived from: (1) monitoring NASA's evolving initiatives in downsizing, re-engineering, commercialization, and privatization to determine opportunities for efficiencies and vulnerabilities; (2) selecting audits and reviews using a structured approach encompassing NASA's programs and operations and an external universe comprised of NASA's prime contractors, their subcontractors, and grantees; (3) addressing issues required by laws and internal regulations; and (4) a review of the Top Ten Management Challenges as provided by the OIG each year to the Congress and the Agency. The audits and reviews identified from these sources are prioritized and published in an updated inventory. The OIG will continue its NASA-wide program-oriented reviews to obtain greater visibility and awareness of issues related to NASA's major programs and initiatives.

Agency vulnerabilities are determined by taking into consideration the following: (1) whether program and project objectives are accomplished in the most cost effective manner and comply with safety and mission quality initiatives; (2) whether management's actions are sufficient to correct internal control weaknesses reported under the Federal Manager's Financial Integrity Act (FMFIA); (3) whether NASA's annual expenditure on information technology is providing expected programmatic and financial information needed to make sound decisions (NASA is one of the top ranked civilian agencies in information technology spending); (4) whether improvements are implemented in financial management systems, practices, controls, and information; (5) whether the audit follow-up system is effective in enabling management to maintain the status of corrective actions; and (6) whether Agency-wide corrective actions addressing environmental concerns are adequate. Each of the identified vulnerabilities are evaluated, prioritized, and included in our plans for further action.

Further, Agency program and project changes, growth, delays, and termination increase the need for OIG oversight of contractor/subcontractor/grantee cost, schedule, and performance effectiveness. The Agency is developing a number of technology programs that will be reaching critical milestones in FY 2002 and beyond that have not received audit coverage. NASA's continued reliance on contractors and grantees (about 86 percent of the Agency's total obligations are for procurement) will require increasing direct OIG involvement and oversight of Defense Contract Audit Agency (DCAA) and Health and Human Services (HHS) OIG audits of NASA contractors and grantees to ensure effective contract and grant execution and administration.

During FY 2002, the OIG will continue to focus attention and provide support to program managers on issues relating to: Earth Science, Space Science, Communications, Human Exploration and Development of Space, with an emphasis on the Space Shuttle and International Space Station programs, Aero-space Technology, Information Technology, and Space Transportation. The functional areas we will evaluate include Procurement and Contract Administration, Technology Transfer, Financial Management, Information Resources Management, Information Systems and Communications Security, and Facilities and Equipment. The OIG's Information Technology Audit Group will continue to focus on the security and integrity of NASA's major information systems and operations. Financial management's significance increased with the passage of the CFO Act. Pursuant to the Inspector General Act, we have selected independent auditors to render an opinion on the Agency's annual financial statements, its internal control structure, and its compliance with laws and regulations. DCAA audit activity and the audit of the annual financial reports required by the CFO Act, also referred to as the Agency Accountability Report, is funded elsewhere in the agency's budget. Our financial audits will concentrate on accounting controls, information systems, and required performance measurements.

The OIG will continue to monitor and assess NASA's high risk areas, material weaknesses, and areas of significant concern to ensure that corrective actions are implemented in a timely manner. Areas of emphasis will include: fiscal management; procurement and environmental programs; safety and mission assurance; biological and physical research; NASA information technology resources and security; institutional contracting practices; contract management; contractor cost reporting; allotment and budgetary controls; and financial reporting/general ledger. The defined audit and review workload far exceeds available staff. Continuous adjustment of priorities will be necessary in order to provide balanced coverage of programs and operations most vulnerable to abuse and mismanagement.

The OIG investigative workload continues to exceed the availability of investigative resources. The FY 2002 investigative staffing level will require OIG management to effectively manage the complex workload of investigative criminal and civil fraud matters. The establishment of the Computer Crimes Division (CCD) allows the OIG to investigate unauthorized intrusions into and compromises of NASA and contractor computer systems, as well as assessing vulnerability to information terrorism. The CCD has an ever-increasing computer crimes investigative caseload. Past and current intrusions involve cyber extortion of NASA and contractor personnel, losses of communications services involving hundreds of thousands of dollars per intrusion, and use of NASA funded networks to further other criminal enterprises including the compromise of advanced technologies and industrial espionage. The number of complex procurement fraud cases also remains high. Such cases take longer to resolve and are resource intensive, thereby limiting our flexibility to expand the program. We are currently proactively focusing on program fraud areas identified by our audits as highly vulnerable to fraud. We are working with management to help us address all substantive allegations received, to refer more routine administrative matters to them for their resolution, and request that they keep the OIG advised of the action taken. Usually, the criminal investigators refer more serious administrative matters to the OIG Office of Inspections, Administrative Investigations, and Assessments (IAIA) staff for review. By referring matters to Agency managers and the IAIA staff to resolve, the OIG can reserve our investigative resources to address the more serious fraud allegations.

In summary, the OIG will continue to: improve scope, timeliness, and thoroughness of its oversight of NASA programs and operations; identify preventive measures; and enhance our capabilities to assist NASA management to efficiently and effectively achieve program and project goals and objectives.

SCHEDULE & OUTPUTS

WORKLOAD	FY 2000	FY 2001	FY 2002
Office Staff Ceiling			
Full-Time Equivalents	192	213	213
Investigations			
Cases pending beginning of year	295	306	319
Opened during the year	172	189	207
Closed during the year	161	176	193
Cases pending end of year	306	319	333
Computer Crimes Division			
Cases pending beginning of year	22	47	102
Opened during year	63	175	250
Closed during year	38	120	150
Cases pending end of year	47	102	202
Audits			
Audits pending beginning of year	37	37	36
Opened during year	62	62	62
Closed during year	62	63	64
Audits pending end of year	37	36	34
Inspections, Administrative Investigations, and Assessments (IAIA)			
IAIA Administrative Investigations pending beginning of year	45	95	140
Opened during year	165	175	183
Closed during year	115	130	170
IAIA Administrative Investigations pending end of year	95	140	153
IAIA Inspections and Assessments pending beginning of year	11	16	17
Opened during year	17	12	14
Closed during year	12	11	13
IAIA Inspections and Assessments pending end of year	16	17	18

BASIS OF FY 2002 FUNDING REQUIREMENT

PERSONNEL AND RELATED COSTS

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Compensation and Benefits	**18,474**	**20,755**	**21,325**
Compensation	14,873	16,687	17,145
(Full-time permanent)	14,792	16,687	17,145
(Other than full-time permanent)	81	0	0
(Overtime & other compensation)	0	0	0
Benefits	3,601	4,068	4,180
Supporting Costs	**212**	**368**	**425**
Transfer of personnel	103	175	200
Personnel training	109	188	220
OPM Services	0	5	5
Total	**18,686**	**21,123**	**21,750**

FULL-TIME EQUIVALENTS

	FY 2000	FY 2001	FY 2002
Full-time permanent	192	213	213
Other controlled FTEs	0	0	0
Total	**192**	**213**	**213**

These estimates provide the resources required for full staffing of NASA OIG's Information Technology Audit and Computer Crimes Divisions.

TRAVEL

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Travel	598	1,098	1,200

Travel funding is required to carry out audit, investigation, inspection and assessment, partnerships and alliances, and management duties. Our budget allows for increases in per diem, airline costs, and workloads. We anticipate increased travel by our information technology audit and computer crimes teams. Also, in order to respond to NASA's changing priorities (and implementation of its centers of excellence and commercialization efforts), increased travel funds will be required to deploy staff located at field offices remote from the site where audit and investigation activities occur.

OPERATION OF INSTALLATION

	FY 2000	FY 2001	FY 2002
	(Thousands of Dollars)		
Technical Services	379	280	300
Management and Operations	337	448	450
Total	716	728	750

Operation of Installation provides a broad range of services and equipment in support of the Office of Inspector General's activities.

The Technical Services estimate provides for all equipment, including purchase, maintenance, programming and operations of unique information technology (IT) equipment. NASA provides common services items such as office space, communications, supplies, and printing and reproduction at no charge to the Office of Inspector General. The funding for Technical Services will cover the cost of providing unique IT upgrades and replacement of unique equipment that has become outdated or unserviceable. As funding permits, in FY 2002, we will proceed with implementation of an OIG virtual private network and secure electronic mail, which is crucial in light of the sensitivity of our investigations, audits, and reviews. Also, we will continue to improve our management information systems and Computer Crimes capabilities.

The Management and Operations category includes miscellaneous expenses within the Office of Inspector General, i.e., GSA cars, the Inspector General’s confidential fund, miscellaneous contracts, and supplies not provided by NASA.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General in carrying out the Inspector General Act of 1978, as amended, [*23,000,000*], *23,700,000* (*Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2000.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CHANGES FROM FY 2001 BUDGET ESTIMATE TO FY 2001 CURRENT ESTIMATE

SUMMARY	FY01 Request	*P.L. 106-377 and other Changes	1/18/01 Initial Op Plan	**P.L 106-554 and other Changes	3/1/01 Op Plan
HUMAN SPACE FLIGHT	5,499.9	-37.0	5,462.9	-12.0	5,450.9
Space Station	2,114.5	3.0	2,117.5	-4.7	2,112.8
Space Shuttle	3,165.7	-40.0	3,125.7	-6.9	3,118.8
Payload & ELV Support	90.2		90.2	-0.2	90.0
Investments & Support	129.5		129.5	-0.3	129.2
Science, Aero & Technology	5,929.4	261.3	6,190.7	-13.6	6,177.1
Space Science	2,398.8	-75.7	2,323.1	-2.1	2,321.0
Biological & Physical Research	302.4	11.2	313.6	-0.7	312.9
Earth Science	1,405.8	82.1	1,487.9	-3.3	1,484.6
Aerospace Technology	1193.0	214.2	1407.2	-3.1	1404.1
Space Operations	529.4	-3.5	525.9	-4.2	521.7
Total Academic Programs	100.0	33.0	133.0	-0.3	132.7
Mission Support	2,584.0	24.7	2,608.7	-6.4	2,602.3
Safety, Mission Assur, Eng & Adv Concepts	47.5		47.5	-0.1	47.4
Research & Program Management	2,290.6	-10.9	2,279.7	-4.3	2,275.4
Construction of Facilities	245.9	35.6	281.5	-2.0	279.5
Inspector General	22.0	1.0	23.0	-0.1	22.9
NASA TOTAL	**14,035.3**	**250.0**	**14,285.3**	**-32.1**	**14,253.2**

**Reflects Congressional direction in VA-HUD-Independent Agencies Appropriations Act and conference report H.R.106-988.*
***Reflects 0.22% rescission and $0.7M transfer to other agencies (P.L. 106-554).*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CHANGES FROM FY 2001 BUDGET ESTIMATE TO FY 2001 CURRENT ESTIMATE

Program Detail	FY01 Request	*P.L. 106-377 and other Changes	1/18/01 Initial Op Plan	**P.L 106-554 and other Changes	3/1/01 Op Plan
HUMAN SPACE FLIGHT	**5,499.9**	**-37.0**	**5,462.9**	**-12.0**	**5,450.9**
Space Station	**2,114.5**	**3.0**	**2,117.5**	**-4.7**	**2,112.8**
Vehicle	442.6		442.6	274.3	716.9
Operations Capability	826.5		826.5	-1.8	824.7
Research	455.4	3.0	458.4	-1.0	457.4
Russian Program Assurance	300.0		300.0	-276.0	24.0
Crew Return Vehicle	90.0		90.0	-0.2	89.8
Space Shuttle	**3,165.7**	**-40.0**	**3,125.7**	**-6.9**	**3,118.8**
Flight Hardware	2,005.9	-31.0	1,974.9	-4.3	1,970.6
Ground Operations	551.8	31.0	582.8	-1.3	581.5
Flight Operations	273.6		273.6	-0.6	273.0
Program Integration	334.4	-40.0	294.4	-0.6	293.8
Facilities Construction	15.6		15.6	-0.0	15.6
Payload & ELV Support	**90.2**		**90.2**	**-0.2**	**90.0**
Payload Carriers & Support	57.0		57.0	-0.1	56.9
Expendable Launch Vehicle Mission Support	33.2		33.2	-0.1	33.1

Program Detail (continued)	FY01 Request	*P.L. 106-377 and other Changes	1/18/01 Initial Op Plan	**P.L 106-554 and other Changes	3/1/01 Op Plan
Investments & Support	**129.5**		**129.5**	**-0.3**	**129.2**
Rocket Propulsion Test Support	28.0		28.0	-0.1	27.9
OSF Contributions to Academic Programs	8.0		8.0	-0.0	8.0
Technology & Commercialization	20.0		20.0	-0.0	20.0
Engineering & Technical Base	73.5		73.5	-0.2	73.3
Science, Aero & Technology	**5,929.4**	**261.3**	**6,190.7**	**-13.6**	**6,177.1**
Space Science	**2,398.8**	**-75.7**	**2,323.1**	**-2.1**	**2,321.0**
Space Infrared Telescope Facility (SIRTF)	117.6	1.0	118.6	-0.3	118.3
Hubble Space Telescope Development	168.1	11.8	179.9	-0.4	179.5
Relativity (GP-B) Mission	13.8	27.5	41.3	-0.1	41.2
SOFIA	33.9	5.1	39.0	-0.1	38.9
TIMED	0.0	9.3	9.3	4.0	13.3
Payload & Instrument Development	7.1	26.4	33.5	-0.1	33.4
Explorer Program	138.8	2.8	141.6	-0.3	141.3
Discovery Program	196.8	-2.5	194.3	18.7	213.0
Mars Surveyor/Mars Exploration Program	326.7	98.8	425.5	2.1	427.6
Mission Operations	80.0	9.5	89.5	-4.2	85.3
Supporting Research & Technology	1,302.8	-265.4	1,037.4	-21.4	1,016.0
Technology Program	(740.3)	(-306.1)	(434.2)	(-15.0)	(419.2)
Research Program	(523.6)	(37.9)	(561.5)	(-6.3)	(555.2)
Suborbital Program	(38.9)	(2.8)	(41.7)	(-0.1)	(41.6)
Space Science Investments	13.2		13.2	0.0	13.2

Program Detail (continued)	FY01 Request	*P.L. 106-377 and other Changes	1/18/01 Initial Op Plan	**P.L 106-554 and other Changes	3/1/01 Op Plan
Biological & Physical Research	**302.4**	**11.2**	**313.6**	**-0.7**	**312.9**
Advanced Human Support Technology	30.9		30.9	-0.1	30.8
Biomedical Research & Countermeasures	76.9	-7.5	69.4	-0.2	69.2
Fundamental Biology	39.2	1.5	40.7	-0.1	40.6
Microgravity Research	129.3	1.7	131.0	-0.3	130.7
Space Products Development	13.6	0.1	13.7	-0.0	13.7
Space Medicine					
Occupational Health	11.3	0.4	11.7	-0.0	11.7
Mission Integration	0.2	15.0	15.2	-0.0	15.2
OBPR Investments	1.0		1.0	-0.0	1.0
Earth Science	**1,405.8**	**82.1**	**1,487.9**	**-3.3**	**1,484.6**
Major Development	819.5	21.5	841.0	-4.2	836.8
Earth Observation System (EOS)	447.1	-48.0	399.1	9.1	408.2
EOS Data Information System (EOSDIS)	252.0	25.0	277.0	-0.6	276.4
Earth Explorers	120.4	44.5	164.9	-12.7	152.2
Research & Technology	533.3	47.7	581.0	-1.3	579.7
Earth Science Program Science	353.2	-1.8	351.4	-0.8	350.6
Applications, Commercialization & Education	69.2	45.2	114.4	-0.3	114.1
Technology Infusion	110.9	4.3	115.2	-0.3	114.9
Mission Operations	42.7	12.9	55.6	2.2	57.8
Earth Science Investments	10.3		10.3	0.0	10.3

Program Detail (continued)	FY01 Request	*P.L. 106-377 and other Changes	1/18/01 Initial Op Plan	**P.L 106-554 and other Changes	3/1/01 Op Plan
Aerospace Technology	**1193.0**	**214.2**	**1407.2**	**-3.1**	**1404.1**
Aerospace Research & Technology	1,058.0	186.4	1,244.4	-2.7	1,241.7
Research & Technology Base	539.4	26.6	566.0	-1.2	564.8
Aerospace Focused Programs	507.4	21.4	528.8	-1.2	527.6
High Performance Computing & Comm	24.2	-2.0	22.2	-0.0	22.2
Aviation Systems Capacity	59.2	9.4	68.6	-0.2	68.4
Aviation Safety	70.0	1.0	71.0	-0.2	70.8
Ultra Efficient Engine Technology	35.0	13.0	48.0	-0.1	47.9
Small Air Transport System	9.0		9.0	0.0	9.0
Quiet Airframe Technology	20.0		20.0	0.0	20.0
2nd Generation RLV	290.0		290.0	-0.6	289.4
Aerospace Technology Investments	11.2		11.2	0.0	11.2
Fundamental Space Base	0.0	98.4	98.4	-0.2	98.2
Space Base NASA Research Announcements	0.0	40.0	40.0	-0.1	39.9
Commercial Technology Program	135.0	27.8	162.8	-0.4	162.4

Program Detail (continued)	FY01 Request	*P.L. 106-377 and other Changes	1/18/01 Initial Op Plan	**P.L 106-554 and other Changes	3/1/01 Op Plan
Space Operations	**529.4**	**-3.5**	**525.9**	**-4.2**	**521.7**
Operations	329.8	16.7	346.5	3.2	349.7
Mission & Data Services Upgrades	106.2	-20.2	86.0	-3.2	82.8
TDRS Replenishment Project	55.0		55.0	-4.1	50.9
Technology	38.4		38.4	-0.1	38.3
Total Academic Programs	**100.0**	**33.0**	**133.0**	**-0.3**	**132.7**
Education Programs	54.1	22.9	77.0	-0.2	76.8
Minority University Research & Education	45.9	10.1	56.0	-0.1	55.9
Mission Support	**2,584.0**	**24.7**	**2,608.7**	**-6.4**	**2,602.3**
Safety, Mission Assur, Eng & Adv Concepts	**47.5**		**47.5**	**-0.1**	**47.4**
Safety and Mission Assurance	25.2		25.2	-0.1	25.1
Engineering	17.5		17.5	-0.0	17.5
Advanced Concepts	4.8		4.8	-0.0	4.8
Research & Program Management	**2,290.6**	**-10.9**	**2,279.7**	**-4.3**	**2,275.4**
Construction of Facilities	**245.9**	**35.6**	**281.5**	**-2.0**	**279.5**
Inspector General	**22.0**	**1.0**	**23.0**	**-0.1**	**22.9**
NASA TOTAL	**14,035.3**	**250.0**	**14,285.3**	**-32.1**	**14,253.2**

**Reflects Congressional direction in VA-HUD-Independent Agencies Appropriations Act and conference report H.R.106-988.*
***Reflects 0.22% rescission and $0.7M transfer to other agencies (P.L. 106-554).*

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SPECIAL ISSUES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 BUDGET ESTIMATES

FULL-COST MANAGEMENT

During 1995, the National Aeronautics and Space Administration (NASA) began a multi-year initiative to introduce full-cost practices into NASA. Full-cost practices involve new management, budgeting, and accounting changes. The changes are designed to provide new, detailed, complete cost information and thereby support improved and more cost effective mission performance and related administrative improvements. Full-cost practices, also referred to as full-cost management, integrate new cost accounting information on all aspects of NASA's activities. This information will help managers ensure that all activities cost-effectively support NASA missions. Full-cost budget information will highlight the full cost, including support costs, of each NASA project and thereby support more complete, "full" disclosure of NASA's activities, clearer linkage between resource inputs and outputs/outcomes, and greater accountability regarding NASA's use of taxpayer resources.

NASA's full cost practices are designed to provide useful, detailed cost information for internal management and appropriate cost information for external oversight. Such information is expected to result in improved decisions and more cost effective mission performance. NASA's practices also comply with related Federal legislation, such as the 1990 Chief Financial Officers (CFO) Act, the 1993 Government Performance and Results Act (GPRA) and the 1996 Federal Financial Management Improvement Act.

The two-appropriation budget merges the previous Mission Support appropriation budget items with the traditional R&D funds on an Enterprise-by-Enterprise basis into individual Mission Support budget lines within each Enterprise. The two appropriation budget in 2002 is the next phase in progressing towards a complete full cost budget. While it does not represent the final goal of a full cost budget at a detailed project/activity level, it does provide significant information to the reader. This FY2002 budget approach continues the progress toward full cost budgeting until the new systems in the Integrated Financial Management Project (IFMP) can be implemented. The "two-appropriation" budget for SAT and HSF also contains a third appropriation for the Inspector General as required by law.

The budgets for each Enterprise have been calculated on the basis of the direct civil service staff required to execute the Enterprise's activities, plus the allocation of the indirect civil service workforce, Research Operations Support (ROS), travel, and non-programmatic CofF based on the relative distribution of direct civil service workforce by Enterprise at each Center. Since the role of Headquarters is considered to be "corporate" in nature supporting the entire Agency, Research and Program Management (R&PM) and Research Operations Support (ROS) funds for Headquarters are allocated based on the relative Enterprise distribution of direct FTE's across the Agency. The final allocation of other-than-direct Mission Support elements is not viable for application back to the program or project level. The Multi-Program Support/Project Management Support that is presently applied against each project in R&D funds will remain in each project's budget, as well as the SOMO mission services that are presently budgeted within each project for this preliminary appropriation structure. The SOMO data services that span across projects and the Safety and Mission Assurance effort will be budgeted within the HSF appropriation.

Implementing the two-appropriation budget involves the distribution of resources to a Center from as many as five Enterprise Mission/Institutional Support budget lines. A formula will be employed to automatically distribute each dollar used by this type of program effort among the five budget lines in the same proportion as originally budgeted among the Enterprises. A basic assumption throughout the use of this two-appropriation process is NASA's ability to exercise transfer authority among the two appropriations within each mission support category of personnel and related costs, travel, ROS, and non-programmatic CofF where the experience of the year will be used to update what was originally planned. While the relative percentage of direct FTE's will be used to allocate the Mission Support funds, there is not a direct one-to-one relationship between the FTE's and the Mission Support allocations, as some of the activities (e.g. IFMP, nonprogram CofF, and Environmental activities such as the Plumbrook decomissioning) are budgeted under Mission Support but not driven significantly by civil service FTE's. The Mission/Institutional Support allocations are also not attributable back to the program or project level once the other-than-direct component of the Research and Program Management (R&PM) and ROS funds are applied.

NASA has tested full-cost concepts across the agency and determined the feasibility of implementation and anticipated benefits, conducting an agency-wide Full Cost Simulation in conjunction with the initial FY 2000 budget request, and conducting full cost data collection in the formulation of the FY 2001 budget. These exercises identified the need for additional process improvements and clarifications in the draft guidance documents. Provided below is a summary of the status, purpose and background of NASA's full-cost initiative. Also highlighted are key legislative authorities that will support the timely, effective implementation of full cost practices in NASA.

Supplemental information is available through the NASA CFO Internet site at http://ifmp.nasa.gov/codeb/initiatives/standard.htm

Purpose

The purpose of the full-cost initiative is to develop and implement full-cost accounting, budgeting, and management practices in NASA. The purpose of implementing these practices is to support cost-effective mission performance through timely, reliable financial information and practices.

Simply stated, full-cost management can be expected to help to ensure optimum mission performance with the minimum essential resources. In that regard, full-cost practices are expected to:

- Support more cost effective mission performance
- Motivate managers to operate efficiently
- Support economic decisions for appropriate resource allocations
- Help justify NASA's budget on a program/project basis
- Support analysis and decision-making regarding full project costs
- Support analysis and decision-making regarding NASA services provided to others (reimbursable activities)
- Support bench-marking of NASA service activities with other similar services
- Strengthen accountability regarding NASA's effective and efficient use of tax dollars to achieve NASA missions.

NASA is pursuing full-cost management at this time because NASA requires related cost information to more effectively manage its programs, especially in terms of finding the most cost effective means for obtaining supporting expertise and capabilities that previously were only available within the NASA infrastructure but may now be found in the marketplace. [However, while NASA may get more information through full ocst management of other cost effective alternatives for obtaining the technical support it needs, this does not preclude the reality of the timeframe associated with making changes to an institution's infrastructure nor adherence to the government's related rules and regulations (e.g. Civil Service Reform Act).

Background

NASA's full-cost management initiative began in 1995 in response to guidance from several NASA and Federal authorities. While the initiative was undertaken in direct response to a specific management initiative of the NASA Administrator, the initiative also responded to guidance indicated in NASA's 1995 Zero Base Review and mandates in several key Federal financial and performance laws and related standards.

In early 1995, the NASA Administrator requested key cost information for NASA and for each NASA Center. In pursuing the Administrator's request, the NASA Chief Financial Officer confirmed that NASA's nonstandard, decentralized accounting systems did not regularly capture all required cost information in a timely, standard, useful manner. Shortly thereafter, in April 1995, NASA initiated its full-cost effort.

During 1995, NASA also completed a Zero Base Review that involved a comprehensive analysis related to streamlining NASA activities. This review also highlighted several weaknesses involving the inconsistent recognition of the total costs of certain NASA activities and the related analytical complications of inconsistent cost information. The Zero Base Review team indicated that NASA should improve cost information and pursue full-cost management.

During 1995, Federal accounting standards-setting organizations also completed key initiatives related to cost accounting. These organizations approved a new managerial cost accounting standard, including a specific standard on full-cost accounting. This standard (and other Federal accounting standards) evolved from recent Federal financial and performance legislation.

During the past few years, financial and performance legislation highlighted key Federal cost accounting and reporting requirements. This legislation included the CFO Act of 1990 and the Government Performance and Results Act of 1993. In addition, more recently the Federal Financial Management Improvement Act of 1996 highlighted and specified other key full-cost accounting requirements. The 1996 Act stated the following.

> "The purposes of this Act are to...require Federal financial systems to support full disclosure of Federal financial data, including the full costs of Federal programs and activities, to the citizens, the Congress, and President, and agency management, so that programs and activities can be considered based on their full costs and merits.".
>
> "Each agency shall implement and maintain management systems that comply substantially with Federal financial management systems requirements, applicable Federal accounting standards, and the United States Government's Standard General Ledger at the transaction level."

NASA's full-cost initiative evolved from these internal NASA initiatives, as well as, several related Government-wide initiatives.

During 1995, NASA developed key full-cost concepts and specified related cost information requirements as part of an ongoing Integrated Financial Management system initiative. NASA's full-cost concepts were approved by NASA management in early 1996.

NASA's full-cost concept integrates several fundamental improvements. The planned improvements include: accounting for all NASA costs as direct costs, service costs, or general and administrative (G&A) costs; budgeting for all appropriate program/project/initiative ("project") costs; and managing such "projects" from a full-cost perspective. Direct costs are costs that can be obviously and/or physically linked to a particular project. Service costs are costs that cannot be initially, readily and/or immediately linked to a cost objective, but subsequently can be traced either to a project or to G&A activities (optimally based on service consumption). G&A costs are support costs that either cannot be to a specific project or where the expense of doing so would be uneconomical. Such costs are typically allocated to cost objectives (or projects) by using allocation methods, which meet the tests of reasonableness and consistency.

During 1996, NASA tested full-cost concepts at four NASA prototype test locations (three Centers and Headquarters). The prototype test indicated that NASA could benefit significantly from the introduction of full-cost practices throughout the agency.

During 1997, NASA completed an agency-wide test of full-cost practices that confirmed its earlier observations that NASA could benefit significantly from the implementation on full-cost practices. The 1997 test also confirmed that NASA needed a new integrated financial system to cost effectively and efficiently support all elements of full cost budgeting and accounting. Cost finding techniques that were used to develop full cost accounting estimates after-the-fact proved to be extremely resource-intensive and could not produce needed data in a timely fashion. Furthermore, the timely, efficient formulation of the budget in a full cost format also proved to be extremely resource-intensive and basically unworkable as an ongoing approach.

Status

During 1998, NASA continued testing and refining full-cost practices. A Full Cost Simulation was conducted across the agency utilizing an early version of the FY 2000 budget proposal. The major focus of this simulation was to determine how best to manage in the full cost environment, particularly in regard to service pools and G&A expense pools. Field Center and Headquarters results and issues were presented to a panel of Deputy Center Directors and Deputy Associate Administrators from throughout the agency, who made management recommendations that were integrated into the agency's Full Cost Implementation Guide.

This 1998 test also served as the first utilization of an early version of a valuable tool in terms of process efficiencies -- the Integrated Financial Management System (IFMS) budget formulation system. NASA used this new budget formulation system to develop and analyze budgetary requirements for the FY 2001 submission.

As an important step in implementing full cost practices, NASA developed the full cost of major programs/projects for FY 1998 and FY 1999, and included this information in its audited financial statements.

In late 1999, NASA reached a consensus that full cost practices should be implemented in an efficient and economical manner, as soon as possible. The basic implementation strategy is to phase key full cost practices into Center and Agency operations over the next few years. Centers were directed to initiate full cost activities with a focus on (1) direct labor cost distribution to projects and (2) G&A and service pool structure standardization in FY 2000 and FY2001. Centers are to capture all direct costs, including labor, by project, and report, on a phased basis, this full cost data to Center project managers.

National Aeronautics and Space Administration

Major NASA Development Programs
Program Cost Estimates

This special section of the FY 2002 budget justifications provides information about major NASA programs that are either in the design and development phase or have not completed their initial operational phase. In several instances, information about programs that are not "major" but are of special interest has been included. The budgetary estimates are expressed in millions of dollars of *budget authority*. * Estimates of the FY 2000 and prior fiscal year budget authority are the "actual" amounts. The FY 2001 amounts are consistent with the latest FY 2001 operating plan. The amounts for FY 2002 and future fiscal years are expressed in "real year" economics, that is, they include an adjusting factor for the future inflation expected to be experienced. If the term "constant dollars" is used in the budget justifications, that phraseology indicates that the numbers do not include inflationary adjustments beyond the fiscal year referenced (e.g., "constant FY 1996 dollars").

The estimates provided below are intended to be comprehensive, including all related mission-unique costs, but there are limitations. The direct and indirect costs incurred by foreign governments or other federal agencies in support of these missions have not been included. The estimates of civil service costs have been included, but these estimates should be considered preliminary, and they will continue to be refined as the agency moves toward full cost accounting over the next several years.

* *Budget authority* is a term used to represent the amounts appropriated by the Congress in a given fiscal year; *budget authority* provides government agencies with the authority to obligate funds. The ensuing obligations, cost incurrence, and expenditures (outlays) can differ in timing from the fiscal year in which Congress provides the *budget authority* in an appropriations act.

Alternate Turbopump Development

Funding to begin development of an alternate design for the two turbopumps driving the Space Shuttle's Main Engine was initiated in FY 1987. The development of a new high-pressure oxygen turbopump and hydrogen fuel turbopump was undertaken to improve the safety, reliability, producibility, and maintainability of the current turbopumps. After an initial period of design and development, problems experienced in early development testing and accompanying increased costs resulted in suspension of the fuel turbopump's development, while development activities concentrated on the oxygen turbopump. Although further development problems were encountered with the oxygen turbopump, their successful resolution led to Congress agreeing in Spring 1994 to resumption of the fuel turbopump's development. The first flight of the oxygen turbopump occurred in 1995, and the initial flight of the fuel pump is currently planned for 2001, rescheduled from late 1997 due to development problems. The budgetary estimate of $980.9 million includes not only the funding required for the design, development, and extensive testing of these two types of turbopumps, but also the funding needed to produce the flight turbopumps for installation into the main engines for the four-orbiter fleet.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT	729.6	21.5	6.2	6.3						763.6
PRODUCTION	157.4	16.5	22.1	21.3						217.3
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	887.0	38.0	28.3	27.6						980.9
(ESTIMATED CIVIL SERVICE FTEs)	(561)	(23)	(19)	(11)						
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	31.9	2.1	1.9	1.1						

Checkout and Launch Control System (CLCS)

A new Checkout and Launch Control System (CLCS) was approved for development at KSC in FY 1997. The CLCS will upgrade the Shuttle launch control room systems with state-of-the-art commercial equipment and software in a phased manner to allow the existing flight schedule to be maintained. The CLCS will reduce operations and maintenance costs associated with the launch control room by as much as 50%, and will provide the building blocks to support future vehicle control system requirements. The Juno and Redstone phases were delivered in FY 1997. In these phases, the initial integration platform was defined, the engineering platform installed and the interface with the math models was established. The Thor delivery was completed in FY 1998. During this phase, initial ground databus interfaces were established and the system software was ported to the production platforms. The Atlas delivery in FY 1999 provided support for the Orbiter Processing Facility were developed, the final applications for the Hypergolic Maintenance Facility, the math model validation, an interface to the Shuttle Avionics Integration Lab (SAIL), and hardware testing for SAIL. The Titan delivery will provide support for completion of development and the start of validation testing for application software used for Shuttle Orbiter power-up testing. The Scout phase of CLCS is planned to support operational use in the Orbiter Processing Facility and development of Pad and launch-related application software. The Delta and Saturn phases include completion of all launch application development, completion of software certification and validation, and a complete integrated flow demonstration. Since the FY 1999 Budget, software independent validation and verification (IV&V) performed by Ames Research Center was also added to this project. By the end of FY 2004, Operations Control Room-1 will be fully operational, followed by certification. The first Shuttle launch using the CLCS is scheduled for FY 2005 with full implementation to be completed one year later.

The budgetary estimates provided below are the amounts included in the Human Space Flight appropriation for this program. This represents an increase of $165.2M over the FY 2001 Budget to Congress estimate of $233.3M. The new launch capable date is 3rd quarter FY 2005 a delta of 37 months. They do not include the amounts for the use of government facilities and general and administrative support used to carry out the development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Shuttle program.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT COSTS	114.8	42.2	55.8	61.0	52.1	37.5	26.6	8.5		398.5
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	114.8	42.2	55.8	61.0	52.1	37.5	26.6	8.5		398.5
(ESTIMATED CIVIL SERVICE FTEs)	(267)	(125)	(118)	(121)	(110)	(78)	(39)	(7)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	21.8	10.5	10.6	11.3	10.8	8.1	4.2	0.8		

TDRS Replenishment Spacecraft Program

The Tracking and Data Relay Satellite (TDRS) Replenishment Spacecraft program ensures sufficient spacecraft will be available to continue Space Network operations into the next century. The program provides three additional TDRS satellites and ground terminal modifications through a fixed price, commercial practices contract with Boeing (previously Hughes Space and Communications Company) company. This innovative approach has deleted or greatly reduced Government specifications and documentation requirements, allowing the contractor to pursue commercial practices; this has resulted in efficiencies in both cost and development lead time.

These satellites will incorporate Ka-band frequencies, where space research has a primary allocation, into the high data rate services provided via the high gain, single access antennas. The single access services at S-band and Ku-band will be retained, remaining backward compatible with the existing, first generation TDRS satellites. These satellites will also provide an enhanced multiple access service with data rates up to three megabits per second. The first spacecraft (TDRS-H) was launched in June 2000. The second spacecraft (TDRS-I) is scheduled for launch in November 2002.

The estimates do not include costs for use of government facilities and general and administrative support used to carry out the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification for the program within the Space Operations section. Projected runout cost estimate has been reduced by $4.1M from last year's estimate due to reduced acquisition costs for the expendable launch vehicle.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
SPACECRAFT DEVELOPMENT AND GROUND TERMINAL MODIFICATIONS	479.6	17.7	14.4	57.7	6.5					575.9
LAUNCH SERVICES	106.9	14.0	36.5	67.8	37.0					262.2
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	586.5	31.7	50.9	125.5	43.5					838.1
(ESTIMATED CIVIL SERVICE FTEs)	(215)	(32)	(30)	(29)	(29)					
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	15.1	3.3	3.2	3.2	3.3					

Earth Observing System

Before the Earth Observing System (EOS) was authorized in November 1990 in the FY 1991 budget as a new start, EOS planning had been in progress for over eight years. The EOS is key to achieving the objectives set forth in the Earth science program plan and the overall goal and scientific objectives of the interagency U.S. Global Change Research Program. EOS is an international science program, drawing upon the contributions of Europe (ESA), Canada, and Japan both in terms of spacecraft and instruments. This extraordinary collaboration is essential to reach the objective of providing comprehensive measurements of the nature of global climate change.

At its outset, the EOS program was based on the flights of two series of large platforms, in addition to platforms from Japan and ESA and instruments carried on Space Station Freedom. The initial estimates provided to Congress focused on the period through fiscal year 2000. The initial estimate of $18-21 billion included development, mission operations, data analysis, launch services, communications, construction of facilities and the amounts carried in the Space Station program for the polar platform's development. In the FY 1992 appropriations process, Congress directed NASA to modify the scope and cost of the program. The cost through FY 2000 was to be reduced by $5 billion, the FY 1993 funding level had to be reduced, and NASA was to examine the feasibility of using smaller platforms. In 1991, the program was restructured to employ five smaller flight series. In 1992, in response to the constrained budget environment, NASA further rescoped the program by implementing a common spacecraft approach for all flights after the first morning (TERRA) spacecraft, increasing reliance on the cooperative efforts of international and other government agencies, and adopting a build-to-cost approach for the first unit of a multiple instrument build. The estimated NASA funding through FY 2000 was further reduced to $8.0 billion in this effort.

In the FY 1995 budget process, the program cost estimate was further adjusted downward by approximately $0.9 billion, of which $0.3 billion reflected an accounting transfer for small business innovative research out of individual programs into a common NASA account, and $0.1 billion reflected the change to lower-cost launch vehicles. The further reductions in program funding were addressed in 1994 through a program rebaselining activity. A number of small spacecraft were introduced into the program flight plans. In addition, alterations were made in flight phasing and accommodations were provided for a follow-on instrument to the enhanced thematic mapper being flown in 1999 on Landsat-7. Funding for the science investigations and data analysis was separated from the algorithms being developed to convert the instrument data into information. This change recognized the close relationship to similar science investigations and data analysis funded in the Earth Science research and analysis account. (The amounts budgeted for EOS science are shown in the table below.) In addition, it was decided to incorporate the development funding for the Landsat-7 into the EOS program in light of the integral ties between the two activities.

In the FY 1996 budget process, the amounts reflected the related program costs for Landsat-7 activities previously funded by the Department of Defense.

The 1997 Biennial Review completed the shift in planning for future missions that began in the 1995 "reshaping" exercise. Emerging science questions drive measurement requirements, which drive technology investments in advance of instrument selection and mission design. Mission design includes such options as purchase of science data from commercial systems and partnerships with other Federal agencies and international agencies. The result is a more flexible and less expensive, approach to acquiring Earth science data.

The ESE recognizes that the pathways of global change research lead from specialized studies of fundamental processes to the integration of individual findings into interactive models of the global Earth system, which can eventually deliver reliable predictions of natural or human-induced environmental phenomena. Long, consistent time-series of global environmental measurements are needed to document changes in forcing parameters and corresponding variations in the state of the Earth system, as required to explore the range of natural variability and test mathematical models of the phenomena. While diagnostic studies based upon long time series of global measurements can reveal the nature of the underlying mechanisms, focused process studies are indispensable to identify and model the basic physical, chemical and biological processes involved. Understanding these component processes is crucial in order to achieve the goal of constructing reliable predictive models of the Earth system. For this reason, the ESE aims to achieve a proper balance between long-term systematic measurements of key forcing or response parameters, and specialized process research. As it deploys EOS, ESE is also planning for the future. The ESE has developed a science research plan, which will drive the selection of the EOS follow-on missions. For example, a Landsat Data Continuity Mission is being formulated in partnership with USGS, and will be implemented as a commercial data purchase if possible. ESE is also planning for the transition of several of its key research observations to the Nation's weather satellite system. The DoD, NOAA and NASA have established an Integrated Program Office (IPO) to create a converged civilian and military weather satellite system called the National Polar-orbiting Operational Environmental Satellite System (NPOESS) to replace the present generation of separate systems. NASA and the IPO are jointly funding the NPOESS Preparatory Project that will simultaneously continue key measurements begun by EOS and demonstrate instruments for NPOESS. The NPOESS Preparatory Project will save money for both organizations by combining essential atmospheric and Earth surface observations on a single platform, and by seeking to meet both climate science and operational weather requirements with the same advanced instruments.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation except for the amount for the Space Station platform. The amounts below reflect the effects of the rescoping of the EOS program, the impacts of the ZBR, and the inclusion of the estimate for FY 2006. They do not include the costs of the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

Earth Observing System	Prior	2000	2001	Subtotal Through FY 2000	2002	2003	2004	2005	2006	Total Through FY 2006
MORNING (Terra)	1,212.6	12.4	3.3	1,228.3	2.4					1,230.7
AFTERNOON (Aqua)	743.4	85.9	53.5	882.8	14.5	2.0	2.0	1.9		903.2
AURA	338.9	112.8	99.5	551.2	80.6	71.7	0.1			703.6
SPECIAL SPACECRAFT	488.3	121.1	111.2	720.6	56.4	21.1	15.9	15.0	14.3	843.3
ICESAT	87.3	52.3	53.3	192.9	12.7					205.6
SEAWINDS	127.6	6.8	5.8	140.2	3.0	1.7	0.5	0.4	0.2	146.0
JASON	50.6	13.1	3.8	67.5						67.5
SORCE		30.2	24.5	54.7	16.7	4.0	2.0	2.0	2.0	81.4
ACRIM	26.0	3.0	1.6	30.6	1.5	1.5	1.3	0.5		35.4
SAGE	64.0	3.0	0.5	67.5	0.1	0.1	0.1	0.1	0.1	68.0
Scisat ELV		3.4	9.6	13.0	9.1					22.1
Other prior (e.g.TRMM CERES/LIS, Solstice, TSIM, SIMBIOS, lightening mapper)	56.2			56.2						56.2
Program support	76.6	9.3	12.1	98.0	13.3	13.8	12.0	12.0	12.0	161.1
QUIKSCAT	84.3	1.1	1.1	86.5	3.3					89.8
LANDSAT 7	439.3	9.8	1.4	450.5	1.7	1.7	1.9			455.8
EOS FOLLOW-ON	8.4	15.0	55.0	78.4	129.6	286.1	322.3	306.6	252.6	1,375.6
ALGORITHM DEVELOPMENT	553.0	121.7	89.3	764.0	83.4	59.8	55.6	52.4	49.0	1,064.2
TECHNOLOGY INFUSION *	234.0	72.6	93.2	399.8	74.2	53.4	65.4	67.8	98.2	758.8
EOSDIS	1,606.8	278.9	281.4	2,167.1	252.7	252.9	282.9	270.9	268.2	3,494.7
SUBTOTAL	5,709.0	831.3	788.9	7,329.2	698.8	748.7	746.1	714.6	682.3	10,919.7
PHASE B	41.0			41.0						41.0
SPACE STATION PLATFORM	104.0			104.0						104.0
EOS SCIENCE	46.4	55.0	48.4	149.8	54.3	53.7	55.7	58.2	60.3	432.0
LAUNCH SERVICES	282.2			282.2						282.2
CONSTRUCTION OF FACILITIES	96.7			96.7						96.7
($M)	6,279.3	886.3	837.3	8,002.9	753.1	802.4	801.8	772.8	742.6	11,875.6
(ESTIMATED CIVIL SERVICE FTEs)	(4,226)	(545)	(478)		(455)	(427)	(410)	(407)	(404)	
CIVIL SERVICE COMPENSATION ESTIMATE ($I	302.7	47.3	43.2		43.5	40.9	39.2	39.0	38.7	

* In FY 01 Submit, Technology Infusion moved to R&T.

EOS New Millennium Program and Technology Infusion

The New Millennium Program (NMP) and Technology Infusion budget reflects a commitment to develop new technology to meet the scientific needs of the next few decades and to reduce future EOS costs. The program objectives are to spawn "leap ahead" technology by applying the best capabilities available from several sources within the government, private industries and universities. The first mission EO-1, has been selected to demonstrate innovative technology to produce Landsat data. The Space-Readiness Coherent Lidar Experiment (SPARCLE) was the second EO mission. The project was terminated due to cost growth. However, the progress in the lidar technology development is still useful for future remote systems. A Geostationary Imaging Fourier Transform Spectrometer was selected as the EO-3 mission. The concept will test advanced technologies such as large area focal-plane array, new data readout and signal processing electronics, and passive thermal switching, which will be used for measuring temperature, water vapor, wind and chemical composition with high resolution in space and time. The EO-3 project is currently in formulation, moving toward a Preliminary Design Review in March 2001.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	TOTAL
EO-1 (INCLUDES LAUNCH SERVICES)	156.6	23.7	10.3						190.6
EO-2 SPARCLE (STS ATTACHED PAYLOAD)	11.4								11.4
EO-3		7.8	34.0	30.0	7.3	13.4	6.6	4.0	103.1
NMP TECHNOLOGY & FUTURE FLIGHTS (INCLUDES LAUNCH SERVICES)	4.7	3.7	5.7	5.8	5.8	11.7	20.9	53.9	112.2
ADV. INFORMATION SYSTEMS TECH.	6.5	12.6	15.4	9.5	9.8	9.8	9.8	9.8	83.2
ADVANCED TECH INITIATIVES	22.0	9.8	12.8	8.9	8.5	8.5	8.5	8.5	87.5
INSTRUMENT INCUBATOR	32.8	15.0	15.0	20.0	22.0	22.0	22.0	22.0	170.8
TOTAL EXCLUDING CIVIL SERVICE COSTS	234.0	72.6	93.2	74.2	53.4	65.4	67.8	98.2	758.8
(ESTIMATED CIVIL SERVICE FTEs)	(224)	(68)	(39)	(30)	(29)	(32)	(30)	(30)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M	17.9	5.9	3.5	2.9	2.8	3.1	2.9	2.9	

Earth Explorers

The Earth Explorer program is the component of Earth Science that addresses unique, specific, highly focused mission requirements in Earth science research. The program is designed to have the flexibility to take advantage of unique opportunities presented by international cooperative efforts, small satellites and advanced technical innovation. Earth Explorers complement the Earth Observing System by enabling investigations needing special orbits or other unique requirements. The missions are developed using short cycles of 1-3 years. The currently approved Earth Explorers are the Total Ozone Mapping Spectrometer (TOMS), Triana, and Earth System Science Pathfinders (ESSP) missions.

The Experiments of Opportunity funding will accommodate opportunities to provide flight instruments and technologies on non-Earth science missions, foreign or domestic, or on airborne experiments. The Lewis and Clark missions were transferred from the Office of Space Access and Technology when that office was dissolved. The LightSAR was cancelled in FY 1999; however, SAR studies will continue under the Technology Infusion Program. The SRTM is a reimbursable mission with the National Imaging and Mapping Agency (NIMA). The UnESS program was cancelled in 2001.

The budgetary estimates below represent funding included in the Science, Aeronautics and Technology appropriation. The program is designed as an ongoing program. The budget estimates immediately below do not include the estimated costs incurred by the international collaborators, mission operations, science costs, related funding included in the Earth Observing System program, use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Earth Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	TOTAL
TOTAL OZONE MAPPING SPECTROMETER (TOMS)	127.3	24.5	0.1						151.9
NASA SCATTEROMETER (NSCAT)	210.0								210.0
TROPICAL RAINFALL MEASURING MISSION (TRMM)	246.0								246.0
TRIANA	35.9	35.1	24.9						95.9
LEWIS & CLARK	130.4								130.4
UNIVERSITY CLASS EARTH SYSTEM SCIENCE (UNESS)		2.3	0.5						2.8
EARTH SYSTEM SCIENCE PATHFINDERS	100.1	90.0	111.5	84.0	121.0	115.7	147.2	167.4	Continues
VCL	42.3	19.0	13.7						75.0
GRACE	45.4	24.6	16.1	6.5	1.6	1.6	0.8	0.2	96.8
PICASSO	5.0	24.8	26.4	29.1	15.8	2.5	2.1		105.7
CLOUDSAT	2.0	19.1	47.6	37.7	18.1	3.1	1.6		129.2
Future Missions/Prog support	5.4	2.5	7.7	10.7	85.5	108.5	142.7	167.2	Continues
LIGHTSAR/SAR DEVELOPMENT	12.0								12.0
EXPERIMENTS OF OPPORTUNITY	5.0	1.0	0.5	0.5	0.4	0.5	0.5	0.5	Continues
SRTM		10.2	3.7						13.9
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	866.7	163.1	141.2	84.5	121.4	116.2	147.7	167.9	
(ESTIMATED CIVIL SERVICE FTEs)	(1015)	(152)	(99)	(76)	(86)	(102)	(121)	(120)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	70.9	13.2	8.9	7.3	8.2	9.8	11.6		

Total Ozone Mapping Spectrometer

The TOMS Earth Probes project is a follow-on to the Total Ozone Mapping Spectrometer (TOMS) instrument flown with such great success on the Nimbus-7 spacecraft in 1978. A TOMS instrument was also flown on the Russian METEOR spacecraft in 1991. The TOMS program consists of a set of instruments (flight models 3, 4, 5) and one small spacecraft. Flight model 3 was launched on the TOMS Earth probe spacecraft on July 2, 1996. Flight model 4 was launched on the Japanese ADEOS spacecraft on August 17, 1996. The ADEOS-I spacecraft failed on June 30, 1997. Flight model 5 has been completed, and was scheduled to fly as a cooperative mission with Russia in late 2000. However, Russia has indicated that it cannot meet that launch date. Presently, the Agency has completed its re-planning and will fly FM-5, as QuikToms, on a U.S. vehicle and spacecraft in June 2001.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
DEVELOPMENT	127.3	24.5	0.1						151.9
MISSION OPERATIONS	2.7	3.2	6.9	6.5	2.7				22.0
SCIENCE TEAMS	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0	7.8
SELV	16.7								16.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	147.6	28.7	8.0	7.5	3.6	1.0	1.0	1.0	198.4
(ESTIMATED CIVIL SERVICE FTEs)	(159)	(19)	(7)	(6)	(6)	(5)	(5)	(5)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	10.9	1.6	0.6	0.6	0.6	0.5	0.5	0.5	

Tropical Rainfall Measuring Mission

The Tropical Rainfall Measuring Mission (TRMM) was launched aboard the Japanese H-II vehicle November 27, 1997. The TRMM development began in FY 1992, after a four-year period of concept studies and preliminary mission definition. The TRMM objective is to obtain a minimum of three years of climatologically significant observations of tropical rainfall. TRMM data will be useful to understand the ocean-atmosphere coupling, especially in the development of El Niño events, which form in the tropics but whose effects are felt globally. The observatory spacecraft was built in-house at the Goddard Space Flight Center. The Japanese built a critical instrument, the Precipitation Radar. Two other instruments are being developed with TRMM program funding, the Visible and Infrared Scanner and TRMM Microwave Imager. In 1992, two EOS-funded instruments were added to the payload, the Clouds and Earth's Radiant Energy System (CERES) and the Lightning Imaging Sensor (LIS). The budget estimates provided below include the costs of accommodating these two instruments on the TRMM observatory. The EOS Data and Information System will have a specific capability for disseminating TRMM data.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	TOTAL
DEVELOPMENT	246.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	246.0
EOS-FUNDED INSTRUMENTS/SCIENCE/DIS	[71.6]								[71.6]
MISSION OPERATIONS	10.9	11.1	14.7	15.6	17.3	8.5	0.0	0.0	78.1
SCIENCE TEAMS	14.3	11.3	16.3	15.7	6.1	0.0	0.0	0.0	63.7
RESEARCH & ANALYSIS-FUNDED SCIENCE	35.4								35.4
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)	306.6	22.4	31.0	31.3	23.4	8.5	0.0	0.0	423.2
(ESTIMATED CIVIL SERVICE FTEs)	(728)	(21)	(20)	(20)	(6)	(4)	(5)	(5)	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	50.2	1.8	1.8	1.9	0.6	0.4	0.6	0.6	

Space Infrared Telescope Facility (SIRTF)

The purpose of the Space Infrared Telescope Facility (SIRTF) mission is to explore the nature of the cosmos through the unique windows available in the infrared portion of the electromagnetic spectrum. SIRTF is the fourth of NASA's Great Observatories, which include the Hubble Space Telescope, the Compton Gamma Ray Observatory, and the Advanced X-Ray Astrophysics Facility. The funding plan provided below reflects a dramatic restructuring of the SIRTF design concept carried for many years. Rather than simply "descoping" the "Great Observatory" concept to fit within a $400 million (FY94 $) cost ceiling (through the end of development) imposed by NASA, scientists and engineers have instead redesigned SIRTF from the bottom-up. The goal was to substantially reduce costs associated with every element of SIRTF -- the telescope, instruments, spacecraft, ground system, mission operations, and project management. The Jet Propulsion Laboratory (JPL) was assigned responsibility for managing the SIRTF project. SIRTF is planned for launch on a Delta launch vehicle in July 2002.

The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out prior to FY 96. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
ATD	79.9									79.9
DEVELOPMENT	189.9	123.4	118.3	105.9						537.5
MISSION OPS					7.0	7.3	6.3	5.3	14.1	40.0
DATA ANALYSIS					61.8	61.2	65.1	64.7	214.8	467.6
TRACKING & DATA SUPPORT					tbd	tbd	tbd	tbd	tbd	tbd
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		123.4	118.3	105.9	68.8	68.5	71.4	70.0	228.9	1125.0
(ESTIMATED CIVIL SERVICE FTEs)	(103)	(25)	(13)	(5)						
CIVIL SERVICE COMPENSATION ESTIMATE ($	3.4	2.3	1.3	0.8						

The Explorer Program

The Explorer program consists of small to mid-sized spacecraft conducting investigations in all space physics and astrophysics disciplines. The program provides for frequent, relatively low-cost missions to be undertaken as funding availability permits within an essentially level overall funding profile for the program. The funding profile provided below covers the design and development phase, launch services, mission-unique tracking and data acquisition support, mission operations and data analysis. It does not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
*Explorers launched before FY 2000 (MO&DA)	226.7	32.7	30.7	26.2	9.5	9.1	6.6	7.4	Continuing	
*Imager for Magnetospause-to-Aurora Global Exploration	129.6	11.2	7.1	7.1	2.5	1.0				158.5
*Microwave Anisotropy Probe	87.9	28.0	22.9	3.7	2.6	0.7				145.8
*Swift Gamma-Ray Burst Explorer		22.2	49.1	47.4	35.2	4.1	3.9	2.8		164.7
*Full-sky Astrometric Mapping Explorer		5.2	20.0	61.7	39.2	32.4	3.7	3.5		165.7
*Small Explorers (HESSI, GALEX, TWINS)	79.7	49.0	41.3	16.7	10.6	6.6	4.4	3.5		204.1
*HETE-II	20.3	5.6	1.5	1.0						28.4
*STEDI (SNOE, TERRIERS, CATSAT, CHIPS & IMEX)	50.0	3.4	11.1	6.2	1.5					38.6
*Planning & Future Developments		3.4	5.7	31.3	121.4	191.5	283.0	316.6	Continuing	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		160.7	189.3	201.3	222.5	245.4	301.6	333.8		
(ESTIMATED CIVIL SERVICE FTEs)		(203)	(210)	(214)	(172)	(152)	(118)	(118)	Continuing	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		16.5	16.4	17.1	15.0	14.0	12.0	12.4	Continuing	

*Tracking estimate is not included

Imager for Magnetopause-to-Aurora Global Exploration

Development on the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) began in FY 1997. The IMAGE mission is using three-dimensional imaging techniques to study the global response of the Earth's magnetosphere to variations in the solar wind, the stream of electrified particles flowing out from the Sun. The magnetosphere is the region surrounding the Earth controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. Southwest Research Institute developed the IMAGE mission, which launched successfully in March 2000 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT	84.5	4.7								89.2
LAUNCH SUPPORT	45.1	1.7								46.8
MISSION OPERATIONS		0.4	0.4	0.1						0.9
DATA ANALYSIS		4.4	6.7	7.0	2.5	1.0				21.6
TOTAL	129.6	11.2	7.1	7.1	2.5	1.0				158.5

Microwave Anisotropy Probe

Development on the Microwave Anisotropy Probe (MAP) began in FY 1997. The MAP mission will undertake a detailed investigation of the cosmic microwave background to help understand the large-scale structure of the universe, in which galaxies and clusters of galaxies create enormous walls and voids in the cosmos. GSFC is developing the MAP instruments in cooperation with Princeton University. MAP will launch in summer 2001 aboard a Delta-7326 (Med-Lite Class ELV).

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT	59.2	13.3	12.1							84.6
LAUNCH SUPPORT	28.7	14.7	6.4							49.8
MISSION OPERATIONS			1.5	2.1	1.5					5.1
DATA ANALYSIS			2.9	1.6	1.1	0.7				6.3
TOTAL	87.9	28.0	22.9	3.7	2.6	0.7				145.8

Swift Gamma-Ray Burst Explorer

Swift is a three-telescope space observatory for studying the position, brightness, and physical properties of gamma ray bursts. Although gamma ray bursts are the largest known explosions in the Universe, outshining the rest of the Universe when they explode unpredictably in distant galaxies, their underlying nature and cause remain mysteries. Swift was selected in October 1999 as a MIDEX mission, and is planned for launch in September 2003.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT		22.2	33.5	30.5	16.2					102.4
LAUNCH SUPPORT			15.6	16.9	17.5					50.0
MISSION OPERATIONS						2.6	1.9	2.0		6.5
DATA ANALYSIS					1.5	1.5	2.0	0.8		5.8
TOTAL		22.2	49.1	47.4	35.2	4.1	3.9	2.8		164.7

Full-Sky Astrometric Mapping Explorer (FAME)

FAME is a space telescope designed to obtain highly precise position and brightness measurements of 40 million stars. This rich database will enable numerous science investigations, including accurately determining the distance to all of the stars on this side of the Milky Way galaxy, detecting large planets and planetary systems around stars within 1,000 light years of the Sun, and measuring the amount of dark matter in the galaxy from its influence on stellar motion. FAME was selected in October 1999 as a MIDEX mission, and is planned for launch in October 2004.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT		5.2	20.0	46.1	20.3	11.2				102.8
LAUNCH SUPPORT				15.6	18.9	19.2				53.7
MISSION OPERATIONS						1.2	1.1	1.2		3.5
DATA ANALYSIS						0.8	2.6	2.3		5.7
TOTAL		5.2	20.0	61.7	39.2	32.4	3.7	3.5		165.7
		48.8	37.0	8.4	2.8	1.4	0.8			

Mars Exploration Program

The newly reformulated Mars Exploration Program is pursuing four major goals and objectives: (1) to determine if life ever arose on Mars, and if it still exists today; (2) to characterize Mars's ancient and present climate and climate processes; (3) to determine the geological processes affecting the Martian interior, crust, and surface; (4) to prepare for human exploration of Mars, primarily through environmental characterization.

The newly restructured Mars Exploration Program (MEP) will deliver a continuously refined view of Mars with the excitement of discovery at every step. The MEP strategy will respond to new science investigations that will emerge as discoveries are made. The strategy is linked to our exploration experience here on Earth, including experience in deep sea exploration and petroleum deposit searches, and uses Mars as a natural laboratory for understanding life and climate on Earth-like planets other than our own.

The basic scientific approach to achieving these goals is one of "Seek, In-Situ, and Sample". In the initial phases – and relying heavily on orbital instruments – the MEP will survey Mars to identify scientifically interesting areas in global context. Following this phase, more detailed measurements will be made by long-lived assets on the surface, allowing in-situ laboratory analyses to refine the interpretations developed during the previous orbital reconnaissance phase and confirm from the ground the observations made in orbit. Finally, samples of scientifically significant components of the Martian atmosphere, surface, and subsurface will be returned to Earth for definitive analytical investigation in ways that are not possible to be performed on the surface of Mars.

The funding profile provided below covers the design and development phase, launch services, mission-unique tracking and data acquisition support, mission operations and data analysis. It does not include all costs for the use of government facilities and general and administrative support required to implement the program. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
MARS GLOBAL SURVEYOR (MGS)	220.5	18.8	17.5	10.2						267.0
1998 MARS ORBITER/LANDER	290.0	6.0								296.0
2001 MARS ODYSSEY	285.9	109.2	47.1	23.1	20.0	20.0	10.6			515.9
2003 MARS EXPLORATION ROVERS (MER)		18.9	302.0	207.0	118.5	48.6	4.7			699.7
FUTURE MISSIONS		121.1	100.5	234.3	364.7	504.9	676.5	565.0	Cont.	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		274.0	467.1	474.6	503.2	573.5	691.8	565.0	Cont.	
(ESTIMATED CIVIL SERVICE FTEs)		(64)	(89)	(97)	(98)	(75)	(75)	(65)	Cont.	
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		5.7	7.1	7.7	8.0	6.6	7.0	6.2	Cont.	

Mars Global Surveyor (MGS)

Mars Global Surveyor (MGS), the first of the MEP missions, is an orbiter that carries a science payload comprised of 5 of the original 8 spare Mars Observer instruments aboard a small, industry-developed spacecraft. MGS was launched successfully in November 1996 aboard a Delta II launch vehicle and has been producing highly valuable science output since it arrived at Mars in September 1997. MGS completed its primary mission on January 31, 2001, and moved immediately into an extended mission phase. In the extended phase MGS will study the most interesting locations on the planet in detail and observe variability on the Martian surface. MGS will also study potential landing sights for the Mars 2003 rovers.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT	130.7									130.7
LAUNCH SUPPORT	52.6									52.6
MISSION OPERATIONS	23.9	12.8	9.1	4.3						50.1
DATA ANALYSIS	13.3	6.0	8.4	5.9						33.6
TOTAL	220.5	18.8	17.5	10.2						267.0

1998 Mars Orbiter/Lander

The ‘98 Mars Orbiter and Lander consisted of the Mars Climate Orbiter (MCO) and the Mars Polar Lander (MPL). MCO was intended to study the planet's weather for one Martian year, acquiring data to help scientists better understand the Martian climate. The MPL was to focus primarily on Mars' climate and water. The MPL mission would search for near-surface ice and possible surface records of cyclic climate change, and characterize physical processes key to the seasonal cycles of water, carbon dioxide and dust on Mars. MCO launched in December 1998 and MPL launched in January 1999; however, both missions failed upon arrival at Mars.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT	189.7									189.7
LAUNCH SUPPORT	90.7									90.7
MISSION OPERATIONS	9.4	5.6								15.0
DATA ANALYSIS										
TRACKING & DATA SUPPORT	0.2	0.4								0.6
TOTAL	290.0	6.0								296.0

2001 Mars Odyssey

The Mars 2001 Odyssey science objective is to determine the elemental and mineral composition of the surface, learn about the landforms, and measure the potential radiation hazards for future human exploration. The 2001 Mars Odyssey Orbiter is scheduled for launch in April 2001, will arrive at Mars in October 2001, and will begin the mapping orbit 45 to 90 days after orbit capture.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT	244.2	89.5	32.4							366.1
LAUNCH SUPPORT	41.7	19.7	5.9							67.3
MISSION OPERATIONS			5.8	14.1	10.4	10.1	3.8			44.2
DATA ANALYSIS			3.0	9.0	9.6	9.9	6.8			38.3
TRACKING & DATA SUPPORT			TBD	TBD	TBD	TBD				
TOTAL	285.9	109.2	47.1	23.1	20.0	20.0	10.6			515.9

2003 Mars Exploration Rovers (MER)

In 2003, two powerful new Mars rovers will be on their way to the red planet. With far greater mobility than the 1997 Mars Pathfinder rover, these robotic explorers will be able to trek up to 100 meters (about 110 yards) across the surface each Martian day. Each rover will carry a sophisticated set of instruments that will allow it to search for evidence of liquid water that may have been present in the planet's past. The rovers will be identical to each other, but will land at different regions of Mars. The rovers will be launched separately in May and June of 2003, and will arrive at Mars in October of 2004.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT		18.9	270.6	169.5	74.1					533.1
LAUNCH SUPPORT	[23.0]	[4.6]	31.4	37.5	32.2					101.1
MISSION OPERATIONS					3.6	27.3	4.7			35.6
DATA ANALYSIS					8.6	21.3				29.9
TRACKING & DATA SUPPORT					TBD	TBD	TBD			
TOTAL		18.9	302.0	207.0	118.5	48.6	4.7			699.7

Future Mars Exploration

Future Mars Exploration funds NASA missions, NASA participation in international cooperative missions to Mars and infrastructure supporting Mars missions, including: 2003 Mars Express (instruments for an ESA mission); 2005 Mars Reconnaissance Orbiter (MRO); 2007 Smart Lander; International Mars missions after 2003 (Telecom mission with ASI, netlander and Orbiter with CNES); U.S. competitively selected Mars missions; the first U.S. Mars Sample Return (MSR) Lander in 2011; Mars technologies; and construction of the Deep-Space-Network (DSN) 34M Beam Wave Guidance (BWG) Antenna to support the additional communications requirements of the new Mars program.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT + LAUNCH SUPPORT		120.7	87.3	223.9	353.6	489.7	658.7	522.1	cont.	
MISSION OPERATIONS		0.4	5.1	3.3	3.6	4.5	6.5	21.9	cont.	
DATA ANALYSIS			8.1	7.1	7.5	10.7	11.3	21.0	cont.	
TRACKING & DATA SUPPORT							TBD	TBD		
TOTAL		121.1	100.5	234.3	364.7	504.9	676.5	565.0		

Discovery Missions

The Discovery program provides frequent access to space for small planetary missions that will perform high-quality scientific investigations. The program responds to the need for low-cost planetary missions with short development schedules. Emphasis is placed on increased management of the missions by principal investigators. Missions are selected through open, peer-reviewed competitions, to ensure science community involvement while enhancing the U.S. return on its investment. The Discovery program also aids in the national goal to transfer technology to the private sector. The cost of building, launching, and operating a Discovery mission must not exceed $300 million in FY 01 dollars and the mission must launch within three years from start of development. Four Discovery missions have been launched: NEAR in February 1996, Mars Pathfinder in December 1996, Lunar Prospector in January 1998, and Stardust in February 1999. In addition, there are two Discovery missions currently in development (Genesis, launching in Summer 2001, and CONTOUR in July 2002), an instrument in development (ASPERA-3, which is to fly on the European Space Agency's Mars Express spacecraft in 2003), and two missions in formulation (MESSENGER, launching in March 2004, and Deep Impact launching in January 2004).

The budgetary estimates provided below are the amounts included in the specific budget justification for this program within the Space Science section in the Science, Aeronautics and Technology appropriation. Under the specific mission descriptions below, all direct program cost elements are included: the development of the spacecraft and experiments, mission operations, launch services and unique tracking and data acquisition services. The data below does not include costs for the use of government facilities and general and administrative support required to implement the program. A more detailed description of the program goals, objectives and activities is provided in the specific budget justification narrative for the program.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
LUNAR PROSPECTOR	63.9	1.4								65.3
NEAR	202.2	13.2	10.0	1.5	3.0	3.0	1.5			234.4
STARDUST	170.7	4.3	4.6	4.3	5.6	6.8	5.6	6.6		208.5
GENESIS	127.3	62.3	32.3	6.9	7.4	2.8	2.1	1.5	0.3	242.9
CONTOUR	9.2	52.2	53.9	26.5	3.9	3.5	1.8	3.4		154.4
DEEP IMPACT	1.5	22.7	72.7	84.2	55.6	21.0	9.6	2.1		269.4
MESSENGER	1.7	9.6	52.0	97.4	64.7	35.2	7.0	6.9	51.7	326.2
FUTURE MISSIONS		3.5	8.9	9.0	99.2	202.3	266.1	273.1	Continuing	
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M)		169.2	234.3	229.8	239.4	274.6	293.7	293.6		
(ESTIMATED CIVIL SERVICE FTEs)		(21)	(18)	(22)	(28)	(53)	(77)	(75)		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		2.1	1.4	1.9	2.7	5.3	8.0	8.2		

Near-Earth Asteroid Rendezvous (NEAR)

The NEAR Shoemaker mission was approved as a new start in FY 1994 as one of the initial Discovery Program missions. The NEAR mission was conducted as an in-house effort at the Applied Physics Laboratory, with many subcontracted subsystems. The NEAR spacecraft was designed to conduct a comprehensive study of the near-Earth asteroid 433 Eros, including its physical and geological properties and its chemical and mineralogical composition. The NEAR spacecraft was launched February 17,1996 on a Delta II launch vehicle. The original opportunity to rendezvous with the asteroid in January 1999 was lost when the spacecraft failed to fire its main engine properly. However, a subsequent firing was successful, and NEAR succeeded in its rendezvous with Eros in February 2000, NEAR performed flawlessly for a year before landing on the asteroid in February 2001. While the spacecraft is no longer operational, a competitive Data Analysis program is planned for the next several years.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT	124.9									124.9
LAUNCH SUPPORT	43.5									43.5
MISSION OPERATIONS	19.3	6.6	5.0							30.9
DATA ANALYSIS	14.0	6.4	4.8	1.5	3.0	3.0	1.5			34.2
TRACKING & DATA SUPPORT	0.5	0.2	0.2							0.9
TOTAL	202.2	13.2	10.0	1.5	3.0	3.0	1.5			234.4

Stardust

The Stardust mission was selected as the fourth Discovery mission in November 1995, with mission management from the Jet Propulsion Laboratory. The mission is designed to gather samples of dust from the comet Wild-2 and return the samples to Earth for detailed analysis. The mission will also gather and return samples of interstellar dust that the spacecraft encounters during its trip through the Solar System to fly by the comet. Stardust is using a new material called aerogel to capture the dust samples. In addition to the aerogel collectors, the spacecraft carries three additional scientific instruments. An optical camera will return images of the comet; the Cometary and Interstellar Dust Analyzer (CIDA) was provided by Germany to perform basic compositional analysis of the samples while in flight; and a dust flux monitor is used to sense particle impacts on the spacecraft. Stardust was launched on a Med-Lite expendable launch vehicle in February 1999 and has been performing well, with return of the samples to Earth expected in January 2006.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
PHASE A/B	9.6									9.6
DEVELOPMENT	116.8									116.8
LAUNCH SUPPORT	40.8									40.8
MISSION OPERATIONS	1.0	1.0	3.8	3.6	4.7	5.2	4.6	5.7		29.6
DATA ANALYSIS	2.5	3.3	0.8	0.7	0.9	1.6	1.0	0.9		11.7
TOTAL	170.7	4.3	4.6	4.3	5.6	6.8	5.6	6.6		208.5

Genesis

In October 1997 NASA selected Genesis as the fifth Discovery mission. The Genesis mission is designed to collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis. It is led by Dr. Donald Burnett from the California Institute of Technology, Pasadena, CA; JPL will provide the payload and project management, while the spacecraft will be provided by Lockheed Martin Astronautics of Denver, CO. Now planned for launch in Summer 2001, it will return the samples of isotopes of oxygen, nitrogen, the noble gases, and other elements to an airborne capture in the Utah desert. Such data are crucial for improving theories about the origin of the Sun and the planets, which formed from the same primordial dust cloud.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
PHASE A/B	11.4									11.4
DEVELOPMENT	115.9	62.3	25.5							203.7
MISSION OPS			3.4	4.0	4.5					11.9
DATA ANALYSIS			2.9	2.4	2.4	2.8	2.1	1.5	0.3	14.4
TRACKING & DATA SUPPORT			0.5	0.5	0.5					1.5
TOTAL	127.3	62.3	32.3	6.9	7.4	2.8	2.1	1.5	0.3	242.9

Comet Nucleus Tour (CONTOUR)

In October 1997 NASA selected CONTOUR as the sixth Discovery mission. CONTOUR's goals are to dramatically improve our knowledge of key characteristics of comet nuclei and to assess their diversity. The spacecraft will leave Earth orbit, but stay relatively near Earth while intercepting at least two comets. CONTOUR builds on the exploratory results from the Halley flybys, and will extend the applicability of data obtained by NASA's Stardust and ESA's Rosetta missions to broaden our understanding of comets. The Principal Investigator is J. Veverka of Cornell University; the spacecraft and project management will be provided by the Johns Hopkins University Applied Physics Laboratory of Laurel, MD. Launch is expected in July 2002.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
PHASE A/B	9.2	0.1								9.3
DEVELOPMENT		52.1	53.9	26.5						132.5
MISSION OPS					2.4	1.9	0.4	1.6		6.3
DATA ANALYSIS					1.5	1.6	1.4	1.8		6.3
TRACKING & DATA SUPPORT					TBD	TBD	TBD	TBD		TBD
TOTAL	9.2	52.2	53.9	26.5	3.9	3.5	1.8	3.4		154.4

Deep Impact

In July 1999 NASA selected Deep Impact as the seventh Discovery mission. It is designed to fire a mssive copper projectile into the comet P/Tempel 1, excavating a large crater more than 65 feet (20 meters) deep, in order to expose the comet's pristine interior ice and rock. This will enable the flyby spacecraft to perform the first-ever study of unaltered cometary material. Deep Impact is led by Dr. Michael A'Hearn of the University of Maryland, College Park, the spacecraft will be provided by Ball Aerospace, and project management will be provided by the Jet Propulsion Laboratory. Launch is expected in January 2004.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
PHASE A/B	1.5	22.7	15.5							39.7
DEVELOPMENT			57.2	84.2	55.6	15.0				212.0
MISSION OPS						4.6	6.9	0.7		12.2
DATA ANALYSIS						1.4	2.7	1.4		5.5
TRACKING & DATA SUPPORT						TBD	TBD	TBD		TBD
TOTAL	1.5	22.7	72.7	84.2	55.6	21.0	9.6	2.1		269.4

Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER)

In July 1999 NASA selected MESSENGER as the eighth Discovery mission. The mission will send an orbiter spacecraft carrying seven instruments to globally image and study the closest planet to the Sun, in order to better understand the forces that have shaped the planet, as well as to better understand the evolution of terrestrial (rocky) planets generally. MESSENGER is led by Dr. Sean Solomon of the Carnegie Institution, Washington, D.C. The spacecraft and project management will be provided by the Johns Hopkins University Applied Physics Laboratory. Launch is expected in March 2004.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
PHASE A/B	1.7	9.6	20.3							31.6
DEVELOPMENT			31.7	97.4	64.7	31.0				224.8
MISSION OPS						2.9	4.2	4.2	23.5	34.8
DATA ANALYSIS						1.3	2.8	2.7	28.2	35.0
TRACKING & DATA SUPPORT						TBD	TBD	TBD	TBD	TBD
TOTAL	1.7	9.6	52.0	97.4	64.7	35.2	7.0	6.9	51.7	326.2

Thermosphere, Ionosphere, Mesosphere Energetics and Dynamics (TIMED)

The TIMED mission is the first science mission in the Solar Terrestrial Probes (STP) Program, and is part of NASA's initiative aimed at providing cost-efficient scientific investigation and more frequent access to space for Sun-Earth Connections missions. TIMED was developed for NASA by the Johns Hopkins University Applied Physics Laboratory (APL). The Aerospace Corporation, the University of Michigan, NASA's Langley Research Center with the Utah State University's Space Dynamics Laboratory, and the National Center for Atmospheric Research provided instruments for the TIMED mission.

TIMED was planned to be ready for launch in May 2000 aboard a Delta II launch vehicle co-manifested with JASON, an Earth Science mission. However, due to Jason's inability to meet the launch date, the TIMED spacecraft is now scheduled for a summer 2001 launch. TIMED began its 36-month C/D development period in April 1997. The budgetary estimates below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from April 1996 to April 1997.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT	123.4	21.4	13.3							158.1
MISSION OPERATIONS				2.0	0.8					2.8
DATA ANALYSIS		0.5	1.0	8.4	8.1	8.1	2.7	2.5		31.3
LAUNCH SUPPORT	24.6	6.1								30.7
TOTAL EXCLUDING CIVIL SERVICE COSTS ($I	148.0	28.0	14.3	10.4	8.9	8.1	2.7	2.5		222.9
(ESTIMATED CIVIL SERVICE FTEs)		25.0	2.0	3.0	3.0	3.0	3.0	3.0		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		2.2	0.4	0.2	0.2	0.2	0.2	0.2		

Stratospheric Observatory for Infrared Astronomy

The initial development funding for the Stratospheric Observatory for Infrared Astronomy (SOFIA) was requested in the FY 1996 budget. This new airborne observatory will provide a significant increase in scientific capabilities over the Kuiper Airborne Observatory, which was retired in October, 1995. The SOFIA will be accommodated in a Boeing 747 and will feature a 2.5-meter infrared telescope to be provided by the German Space Agency (DLR). SOFIA will conduct scientific investigations at infrared and submillimeter wavelengths.

The budget estimates provided below are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the costs of preliminary design studies carried out in previous years, the amounts being contributed by the international participants, or costs for the use of government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the Space Science section.

(Budget Authority in Millions of Dollars)

	PRIOR	2000	2001	2002	2003	2004	2005	2006	BTC	TOTAL
DEVELOPMENT	148.3	42.0	38.9	37.0	42.9					309.1
MISSION OPERATIONS						40.4	42.7	42.8	CONT.	CONT.
TOTAL EXCLUDING CIVIL SERVICE COSTS	148.3	42.0	38.9	37.0	42.9	40.4	42.7	42.8		
(ESTIMATED CIVIL SERVICE FTEs)		73.0	65.0	42.0	23.0	23.0	23.0	23.0		
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		7.0	6.4	4.5	2.5	2.6	2.8	3.0		

Deep Space 1

Deep Space 1 was selected in FY 1996 as the first New Millennium Program mission. DS 1 launched in October, 1998 on a Med-Lite-class Delta launch vehicle. All technologies completed their validation by the end of FY 1999 and included solar electric propulsion, an advanced solar array, autonomous primary navigation, and a miniature imaging camera spectrometer. The DS 1 mission has been extended to utilize its new technologies in a comet flyby. The supplemental technology development line below contains funding for crosscutting technology development efforts previously managed by the Office of Space Access and Technology.

(Budget Authority in Millions of Dollars)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT	99.3									99.3
SUPPLEMENTAL TECH DEV (included in Dev	[14.9]									[14.9]
MISSION OPERATIONS	8.1	3.0	2.1	0.3						13.5
DATA ANALYSIS	1.5	1.9	3.2	0.3						6.9
LAUNCH SUPPORT	45.4									45.4
TRACKING & DATA SUPPORT	0.3									0.3
TOTAL		4.9	5.3	0.6						165.4

Relativity Mission/Gravity Probe-B

The development of the Relativity mission began in 1993, after many years of studying mission design alternatives and developing the advanced technologies required for this mission to verify Einstein's theory of general relativity. The award of the spacecraft development contract was made in 1994. The scheduled launch date is October 2002, using a Delta II launch vehicle. This launch date reflects a two-year slip from the original baseline date for launch of the Relativity Mission. NASA has rebaselined the mission and is continuously monitoring all critical milestones, in particular the following:

- Milestone #18 – Post Acoustic Functional Testing Complete - March, 2001
- Milestone #23 – Integrated Payload Testing Complete - September, 2001

Should the program miss any of the above milestones or should cost trends become unfavorable, NASA will review the impact. Depending upon the assessment of the impact, NASA may initiate a termination review for Gravity Probe-B.

The estimates provided below include funding for the experiment development activities, a minimum of 16 months of mission operations, and the launch services. These estimates are the amounts included in the Science, Aeronautics and Technology appropriation for this program. They do not include the amounts for the definition phase studies carried out from FY 1985-87, but they do provide the amounts for the Shuttle Test of Relativity Experiment program initiated in FY 1988 and subsequently restructured into a ground test program only. The estimates also exclude the non-program-unique government facilities and general and administrative support used to carry out the research and development activities. A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the Space Science section.

(Budget Authority in Millions)

	PRIOR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**BTC**	**TOTAL**
DEVELOPMENT	434.7	41.5	38.6	35.2	9.1					559.1
MISSION OPERATIONS					2.0	1.0				3.0
DATA ANALYSIS					13.6	4.0				17.6
LAUNCH SUPPORT	38.9	8.4	2.6	5.0						54.9
TRACKING & DATA SUPPORT					TBD	TBD				
TOTAL EXCLUDING CIVIL SERVICE COSTS ($M	473.6	49.9	41.2	40.2	24.7	5.0				634.6
(ESTIMATED CIVIL SERVICE FTEs)	(107)	(9)	(22)	(18)	(8)					
CIVIL SERVICE COMPENSATION ESTIMATE ($	7.1	0.9	2.1	1.8	0.8					

X-33 Advanced Technology Demonstrator

The X-33 was an integrated technology effort to flight-demonstrate key technologies required for the next generation of reusable launch vehicles (RLV). In FY 2000 one of the X-33's composite hydrogen tanks failed when the tank lobe's inner skins cracked at cryogenic temperatures, allowing liquid hydrogen leakage. This failure caused a significant slip in the program's schedule, and major rework/redesign was required. In September 2000, NASA and Lockheed Martin agreed on a path forward for the X-33 program. Based on that agreement, the focus of the program concentrated in two areas: completing the redesign and beginning the production of replacement liquid hydrogen tanks, and qualifying the flight engines for the X-33 vehicle. It was also agreed that NASA would commit no additional funding to the X-33: any NASA funds above the amount included in the initial cooperative agreement would come only from selection of the X-33 as part of the openly competed 2nd Generation RLV NASA Research Announcement (NRA) 8-30 procurement. As announced in February 2001, the X-33 program was not selected for additional funding in the 2nd Generation procurement, as NASA determined that the benefits to be derived from continuing the program did not warrant additional government investment. Therefore, the X-33 program comes to completion when the cooperative agreement between NASA and Lockheed Martin expires on March 31, 2001.

The X-33 program also funded refurbishment of rocket engine test stands at Stennis Space Center in FY 1997 ($2.3 million) and FY 1998 ($3.7 million) to enable testing of X-33 development and flight engines, as well as other future advanced space transportation engines. Civil Service estimates below are for the X-33 cooperative agreement only.

(Budget Authority in Millions of Dollars)

X-33	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
COOPERATIVE AND TASK AGREEMENTS	805.1	79.2							884.3
OTHER X-33 ACTIVITIES	95.5	5.4							100.9
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	900.6	84.6	0.0	0.0	0.0	0.0	0.0	0.0	985.2
ESTIMATED CIVIL SERVICE FTEs *	1,019	161	22	8	8	8	7	0	1,233
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	80.6	13.8	2.1	0.8	0.9	0.9	0.8	0.0	99.9

* FTE estimates assumed continuation of the X-33 program past March 31, 2001. The decision not to continue past March 31, 2001 was made too late to fix the Agency FTE totals for this budget. The Civil Service personnel will be reallocated during FY 2003 Budget formulation.

X-34 Advanced Technology Demonstrator

The X-34 objective was to demonstrate technologies and operations concepts with the goal of reducing space transportation costs to one tenth of their current level. The Pathfinder Program formally managed the X-34 project. In FY 2000, the program was thoroughly reviewed by a NASA Risk Evaluation team. The NASA and Orbital Sciences Corporation review revealed the need to redefine the project scope, budget, and schedule. The redefined project included additional risk reduction hardware and testing that would significantly improve the likelihood of mission success. NASA required that the X-34 compete for the funds to undertake these risk reduction tasks as part of the 2nd Generation RLV Risk Reduction NRA 8-30 procurement. In February 2001, NASA announced that the X-34 work had not been selected, as NASA determined that the benefits to be derived from continuing the program did not warrant additional government investment. NASA's Office of Aerospace Technology decided to terminate the project in March 2001.

(Budget Authority in Millions of Dollars)

X-34	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
CONTRACT OBLIGATIONS (ORBITAL)	70.0	15.1	5.6						90.7
OTHER X-34 ACTIVITIES	53.0	49.2	12.3						114.5
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	123.0	64.3	17.9	0.0	0.0	0.0	0.0	0.0	205.2
ESTIMATED CIVIL SERVICE FTEs *	82	133	108	60	40	0	0	0	423
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	8.4	13.7	11.1	6.1	4.1	0.0	0.0	0.0	43.4

* FTE estimates assumed continuation of the X-34 program past March, 2001. The decision not to continue past March, 2001 was made too late to fix the Agency FTE totals for this budget. The Civil Service personnel will be reallocated during FY 2003 Budget formulation.

X-37 Advanced Technology Demonstrator

The X-37 Space Plane is a flying testbed, a modular demonstrator vehicle that will be the first experimental X-vehicle to be flown in both orbital and reentry environments. This project is being worked under a cooperative agreement with the Boeing Co. of Seal Beach, CA. The DoD has provided additional funds, for a number of technologies of interest to them. Currently, the X-37 is slated to fly two missions on the Space Shuttle, beginning in 2003. However, results from the Second Generation Program's NRA8-30 procurement could influence not only these plans, but also future plans for the X-37.

In FY2001, approach and landing tests of the X-40A will be completed and X-37/Shuttle integration analyses will continue. Trade studies for alternate launch platforms such as an Expendable Launch Vehicle (ELV) will also be initiated. Fabrication, assembly and integration of the X-37 will be completed and the X-37 will be rolled out and pre-flight ground tests will begin. In FY 2002, the X-37 program will start approach and landing test flights and preparations for the first Shuttle or ELV flight will begin.

(Budget Authority in Millions of Dollars)

X-37	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
X-37 ACTIVITIES	23.7	22.4	41.4	23.8	20.6				131.9
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	23.7	22.4	41.4	23.8	20.6	0	0	0	131.9
(ESTIMATED CIVIL SERVICE FTEs		95	107	70	40	0	0	0	312
CIVIL SERVICE COMPENSATION ESTIMATE ($M)		9.0	10.1	6.7	3.8	0.0	0.0	0.0	29.6

Space Launch Initiative

Low-cost, reliable space transportation remains the key enabler of a more aggressive civil space program. The 2nd Generation RLV program will substantially reduce the technical, programmatic and business risks associated with developing a safe, reliable and affordable 2nd Generation RLV architecture. The program will invest in the technology, design, and advanced development efforts to enable at least two competitive options for a new architecture. By the 2005 time frame, NASA plans to enable full-scale development of commercially competitive, privately owned and operated, Earth-to-orbit Reusable Launch Vehicles (RLVs). The objective will be to dramatically improve safety while significantly reducing the cost of launch services.

The 2nd Generation RLV Program is divided into major investment areas: Systems Engineering and Requirements Definition, RLV Competition and Risk Reduction, NASA Unique Systems, Alternate Access to Station (AAS), and the Pathfinder program.

The Systems Engineering and Requirements Definition effort is critical to establishing vehicle requirements to guide investments. This activity will combine industry and government capabilities to develop detailed technical and programmatic requirements necessary to link technology and other risk reduction efforts to competing architectures. This effort will place a priority on industry and NASA systems engineering activities that seek compatible architectural solutions between commercial industry and NASA requirements. Of paramount importance is achieving significant improvements in safety, reliability and affordability.

The RLV Competition and Risk Reduction component is designed to allow the U.S. space launch industry to pursue significant technical and economic improvements. These advances must sufficiently reduce risk in order to enable a competition around 2005. NASA will pursue risk reduction efforts that will enable at least two competing architectures. The investment in 2nd Generation RLV risk reduction will be driven by the collective efforts of industry and the government and will be based on NASA needs and competing industry concepts. The risk reduction activities will include technology investments, advanced development activities and flight demonstrations or experiments. Planning calls for multiple industry awards with sufficient government insight to assure success. Government partnerships will be established to obviate redundant proprietary development paths and maximize government return on investment. The selection of industry and NASA investments will be defined consistent with the results of the Systems Engineering and Requirements Definition activities and will be demonstrated (e.g., ground, flight, scale) in the most efficient and cost-effective manner.

NASA Unique Systems is concentrated on developing and demonstrating the designs, technologies and systems level-integration issues associated with NASA-unique transportation elements and systems. This element will address the additional systems (e.g. crew transport vehicle, cargo carriers, rendezvous and docking systems) necessary to meet unique NASA mission requirements (e.g. crew transport, cargo return, emergency rescue and return, on-orbit service) using commercial launch vehicles. The content of this program element will be defined through the systems engineering and requirements definition process and will be concurrent with the RLV Competition and Risk Reduction activities. NASA will seek the development of unique assets that could be operated in conjunction with multiple commercially provided RLV assets. This program element will consist of contracted efforts in combination with government design, development and integration activities. Solicitations for industry involvement are being conducted in parallel with the RLV Competition and Risk Reduction solicitations.

The fourth program element, Alternate Access to Station, seeks to take advantage of all potential sources of access to space on U.S. launch systems to meet the Agency's requirements. This element supports use of existing and emergent commercial launch vehicles that could launch NASA science payloads and potentially service Space Station requirements and includes necessary risk reduction activities to meet NASA's requirements. NASA will use the Next Generation Launch Services (NGLS), Small Expendable Launch Vehicle Service (SELVS), and NASA Launch Services (NLS) acquisition path as a means to develop contractual relationships with multiple emerging and existing U.S. vendors to meet this objective. These contracts will be for fixed-price services for indefinite delivery indefinite quantity launch contracts.

The Pathfinder program was a separate focused activity in prior years, but has now been consolidated within the 2nd Generation RLV program, in keeping with the common objectives of both activities. The objective of the Pathfinder program is to flight-demonstrate advanced space transportation technologies through the use of flight experiments and experimental vehicles, in support of the goal of dramatically reducing the cost of access to space.

(Budget Authority in Millions of Dollars)

Space Launch Initiative	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
SYSTEMS ENGINEERING & REQUIREMENTS DEFINITION	0.0	0.0	49.9	50.0	25.0	10.0	10.0	20.0	164.9
RLV COMPETITION & RISK REDUCTION	0.0	0.0	94.8	287.0	556.0	811.0	599.0	789.0	3,136.8
NASA UNIQUE SYSTEMS	0.0	0.0	41.7	78.8	109.0	130.0	390.0	390.0	1,139.5
ALTERNATE ACCESS TO STATION	0.0	0.0	39.9	34.2	54.4	60.0	65.0	65.0	318.5
PATHFINDER	36.0	34.5	45.2	25.0	20.6				161.3
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	36.0	34.5	271.5	475.0	765.0	1,011.0	1,064.0	1,264.0	4,921.0
(ESTIMATED CIVIL SERVICE FTEs	0	107	223	187	188	153	153	153	1,164
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	9.8	21.9	18.7	19.7	17.3	18.1	19.0	124.5

AVIATION SYSTEMS CAPACITY

The goal of the Aviation System Capacity (ASC) program is to enable safe increases in the capacity of major US and international airports through both modernization and improvements in the Air Traffic Management System, and through the introduction of new vehicle classes that can potentially reduce congestion.

The FAA "Aerospace Forecasts 2000-2011" report predicts that U.S. scheduled domestic enplanements will increase 55% over the next 12 years. Flight delays continue to escalate. The number of delayed flights in the National Airspace System has more than doubled in just the last 6 years. Due to environmental issues and cost, only one major new U. S. airport – in Denver – was opened this past decade. With little ability to build new or expand current airports in the populated areas where they are needed, the capacity of the nation's air transportation system will not meet consumer demand, airport delays will continue to accelerate, and the nation's economy will be adversely impacted.

To meet these growing capacity demands, more efficient and flexible routing, scheduling, and sequencing of aircraft in all weather conditions are critically needed. The ASC program is composed of the Terminal Area Productivity (TAP), Advanced Air Transportation Technologies (AATT), the Aviation System Technology Advanced Research (AvSTAR), and the Short Haul Civil Tiltrotor (SHCT) projects. The TAP project, which was completed in FY 2000, developed revolutionary technology and procedures to enable safe clear-weather airport capacity in instrument weather conditions. The AATT project develops decision-making technologies and procedures to enable substantial increases in the throughput, predictability, flexibility and efficiency of the national air transportation system in the context of the FAA commitment to "Free Flight". The SHCT project develops technologies and procedures to overcome the most critical inhibitors to a civil tiltrotor operating within an improving and modernized air traffic system. The AvSTAR Project will develop revolutionary new operational concepts for the aviation system beyond "Free Flight" and the capability to validate these concepts and their benefits in high fidelity simulation and modeling. The ASC program works closely with manufacturers, the airlines, the FAA, and the technology customers who collectively will identify operational requirements and will apply candidate technologies as operational systems.

(Budget Authority in Millions of Dollars)

ASC	PRIOR	2000	2001	2002	2003	2004	2005	2006	TOTAL
AATT	96.9	45.0	59.8	77.6	71.6	53.1			404.0
TAP	97.8	9.7	5.4						112.9
CIVIL TILTROTOR	48.6	8.2	3.2						60.0
VIRTUAL AIR SPACE MODELING				23.0	23.0	23.0	51.0	70.0	190.0
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	243.3	62.9	68.4	100.6	94.6	76.1	51.0	70.0	766.9
(ESTIMATED CIVIL SERVICE FTEs	0	245	196	221	225	218	197	197	1499
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	23.4	18.7	21.1	21.2	20.6	18.8	18.8	142.6

Aviation Safety Program

The worldwide commercial aviation major accident rate has been nearly constant over the past 2 decades. While the rate is very low (approximately one hull loss per 2 million departures), increasing traffic over the years has resulted in the absolute number of accidents also increasing. The worldwide demand for air travel is expected to increase even further over the coming 2 decades - more than doubling by 2017. Without an improvement in the accident rate, such a traffic volume would lead to 50 or more major accidents a year — a near weekly occurrence. Given the very visible, damaging, and tragic effects of even a single major accident, even approaching this number of accidents would clearly have an unacceptable impact upon the public's confidence in the aviation system, and impede the anticipated growth of the commercial air-travel market. The safety of the general aviation (GA) system is also critically important. The current GA accident rate is many times greater than that of scheduled commercial transport operations. The GA market may grow significantly in future years. Safety considerations must be removed as a barrier if this growth is also to be realized. Controlled-Flight Into Terrain (CFIT) and loss of control are the two largest commercial accident types, with weather, approach and landing, and on-board fire as additional significant categories. Human error is cited above all other issues as the prime contributing factor. For GA, weather issues, CFIT, and loss of control also dominate the accident statistics.

In February 1997, to aggressively address these issues, a national goal was announced to reduce the fatal accident rate for aviation by 80% within 10 years. This national aviation safety goal is an ambitious and clear challenge to the aviation community. NASA responded to the challenge with an immediate major program planning effort to define the appropriate research to be conducted by the Agency. Four industry- and government-wide workshops were conducted in early 1997 to define research needs. Four hundred persons from over one hundred industry, government, and academic organizations actively participated in setting the research investment strategies. This led to NASA's aviation safety initiative and a redirection of the Aeronautics Research and Technology Base in FY 1998 to immediately augment aviation safety research. The Aviation Safety Program (AvSP) is NASA's next step in responding to the challenge. The goal of the AvSP is to develop and demonstrate technologies that contribute to a reduction in the aviation accident fatal rate by a factor of 5 by the year 2007 compared to the 1994-1996 average.

(Budget Authority in Millions of Dollars)

AvSP	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
FOCUSED PROGRAM		64.4	70.8	70.0	85.0	87.3	114.0	100.0	591.5
R&T BASE PROGRAM (NOT INCLUDED ABOVE)	108.2	31.3	30.3	27.0					196.8
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	108.2	95.7	101.1	97.0	85.0	87.3	114.0	100.0	788.3
ESTIMATED CIVIL SERVICE FTEs	0	262	254	246	246	276	242	237	1763
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	25.0	24.2	23.4	23.8	26.0	24.2	21.8	168.4

Ultra-Efficient Engine Technology

The attainment of Aerospace Technology Enterprise goals requires comprehensive propulsion technology research and development spanning a broad range of aircraft applications. The timing is right to invest in breakthrough technologies for a new breed of radically improved propulsion systems to power a new generation of aircraft required in the increasingly constrained airspace system.

The Ultra-Efficient Engine Technology Program addresses the most critical propulsion issues facing the Nation in the new millennium: performance and efficiency. In order to sustain the desirable forecasted in the Nation's air system, performance and efficiency must improve without incurring environmental penalties. Additionally, it is important to sustain high reliability and safe operation without impacting the economics of operations. These propulsion technologies will also be of significant benefit to military engines where performance improvement is the principal goal driving DoD propulsion development for future military aircraft.

(Budget Authority in Millions of Dollars

UEET	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
UEET PROGRAM	0.0	68.3	47.9	40.0	50.0	50.0	50.0	50.0	356.2
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	0.0	68.3	47.9	40.0	50.0	50.0	50.0	50.0	356.2
(ESTIMATED CIVIL SERVICE FTEs	0	262	254	246	246	276	242	237	1763
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	25.0	24.2	23.4	23.8	26.0	24.2	21.8	168.4

High Performance Computing And Communications

The main objective of the Federal HPCC R&D programs has been to extend U.S. technological leadership in high-performance computing and computer communications. As this has been accomplished, these technologies were widely disseminated to accelerate the pace of innovation and improve national economic competitiveness, national security, education, health care, and the global environment.

NASA's primary contribution to the Federal program has been its leadership in the development of algorithms and software for high-end computing and communication systems which will increase system effectiveness and reliability, as well as support the deployment of high-performance, interoperable, and portable computational tools. As HPCC technologies have been developed, NASA has been using them to address aerospace transportation systems, Earth sciences, and space sciences research challenges. The HPCC Program has supported research, development, and prototyping of technology and tools for education, with a focus on making NASA's data and knowledge accessible to America's students.

In support of these objectives, the NASA HPCC Program has developed, demonstrated, and prototyped advanced technology concepts and methodologies, provided validated tools and techniques, and responded quickly to critical national issues. As technologies have matured, the NASA HPCC Program has facilitated the infusion of key technologies into NASA missions activities, the national engineering, science and education communities, and the American public. The Program is conducted in cooperation with other U.S. Government programs, U.S. industry, and the academic community.

To focus on higher priority information technology investments, the Computational Aeroscience, NASA Research and Education Network and Remote Exploration and Experimentation projects will be terminated at the end of FY 2001.

(Budget Authority in Millions of Dollars)

HPCC	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
COMPUTATIONAL AEROSCIENCE	234.7	24.2	22.2						281.1
INFO INFRASTRUCTURE & APPLICATIONS	23.4								23.4
NASA RESEARCH & EDUCATION NETWORK	4.1	4.4	2.9						11.4
EARTH & SPACE SCIENCES	145.9	21.9	21.8	21.8	21.8	11.2			244.4
REMOTE EXPLORATION & EXPERIMENTATION	18.8	14.6	18.9						52.3
LEARNING TECHNOLOGY	21.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	49.0
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	447.9	69.1	69.8	25.8	25.8	15.2	4.0	4.0	661.6
(ESTIMATED CIVIL SERVICE FTEs	32	149	151	31	31	31	2	0	427
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	10.9	10.5	2.2	2.3	2.4	0.5	0.5	29.3

Hypersonic-X (Hyper-X)

The Hypersonic research program is designed to validate the technologies required to test flight a ramjet to scramjet engine transformation, while in-flight. The first flight-test for the Hypersonic-X Research Vehicle (HXRV) was delayed until FY 2001 due to an additional workload supporting an increase for safety and risk mitigation to ensure mission success.

Hyper-X is part of the Vehicle Systems Technology program, which is focused on development of revolutionary new technologies to improve the performance of air vehicles and space transportation vehicles that support Aerospace Enterprise Goals and Objectives. Tasks include the first flight of the Mach 7 Hyper-X vehicle and first flight at Mach 10.

(Budget Authority in Millions of Dollars)

Hyper-X	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
HYPER-X PROJECT	99.0	44.6	31.1	8.0					182.7
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	99.0	44.6	31.1	8.0	0.0	0.0	0.0	0.0	182.7
(ESTIMATED CIVIL SERVICE FTEs *									
CIVIL SERVICE COMPENSATION ESTIMATE ($M) *									

* HYPER-X is a project within the Vehicle Systems Technology program: NASA tracks Civil Service FTEs and compensation only down to the program level, thus no separate data is available for HYPER-X

Environmental Research & Sensor Technology (ERAST)

The ERAST Project is a part of the Flight Research Base R&T Program which continued, during Fiscal year 2000, to safely conduct, enable, and improve NASA's atmospheric flight research capability. Research activities were conducted in the Environmental Research Aircraft and Sensor Technology (ERAST) project with the initial low-altitude flights of the Helios aircraft, which has a 247-foot wingspan and an ultimate altitude goal of 100,000-feet. Preparations are underway to ship the Helios flight and ground support equipment for the summer 2001 deployment where flight to 100,000 feet altitude will be demonstrated. Full deployment will be completed in April 2001. Low-altitude flights are expected to begin late May 2001. The Helios aircraft has commercial market potential as a communications relay platform and Dryden has prepared an implementation approach to Helios technology commercialization for the NASA technology/commercialization office. As a highlight of ERAST FY 2000 flight activities, Dryden completed a GPRA milestone of demonstrating over-the-horizon control of a remotely piloted aircraft outside of controlled airspace using commercial satellite networks. This milestone validated a technology to meet the Earth Science Enterprise requirements for research aircraft to conduct in-situ atmospheric data collection. Also within the ERAST project, the Predator B successfully completed its initial flights in early February 2001. This is a significant achievement towards completing the September 2002 milestone of flight -demonstrating RPA capability to conduct science missions.

(Budget Authority in Millions of Dollars)

ERAST	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
BOLD ERAST	86.1	20.0	13.0	10.5					129.6
ERAST II			12.0	11.5	20.0				43.5
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	86.1	20.0	25.0	22.0	20.0	0.0	0.0	0.0	173.1
(ESTIMATED CIVIL SERVICE FTEs *									
CIVIL SERVICE COMPENSATION ESTIMATE ($M) *									

* ERAST is a project within the Flight Research program: NASA tracks Civil Service FTEs and compensation only down to the program level, thus no separate data is available for ERAST.

Quiet Aircraft Technology Program

The goal of the Quiet Aircraft Technology program is to contribute to the objectives of the Global Civil Aviation enabling technology goals, as stated in the Office of Aerospace Technology Enterprise Strategic Plan, "Reduce the perceived noise levels of future aircraft by a factor of two from today's subsonic aircraft within ten years, and by a factor of four within 25 years." Achievement of the 25-year goal will fulfill NASA's vision of a noise constraint-free air transportation system with the objectionable aircraft noise contained within the airport boundaries. Part of this vision is a transportation system with no need for curfews, noise budgets, or noise abatement procedures. Benefits to the public of achieving these goals include increased quality of life, readily available and affordable air travel, and continued U. S. global leadership.

(Budget Authority in Millions of Dollars)

QAT	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
QUIET AIRCRAFT TECHNOLOGY PROGRAM	0.0	18.3	20.0	20.0	20.0	20.0	20.0	20.0	138.3
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	0.0	18.3	20.0	20.0	20.0	20.0	20.0	20.0	138.3
(ESTIMATED CIVIL SERVICE FTEs	0	0	5	5	5	5	5	5	30
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	0.0	0.5	0.5	0.6	0.6	0.6	0.6	3.4

Small Air Transport System

The goal of the five-year Small Aircraft Transportation System program is to develop key airborne technologies and provide a proof-of-concept evaluation for precision guidance of small aircraft to virtually any touchdown zone at small airports. The objective is to allow the use of underutilized airports (including those without control towers, radar, or precision instrument approaches) as well as underutilized airspace (such as the low-altitude, non-radar airspace below 6,000 feet and the enroute structure below 18,000 feet). If successful, the initial SATS operating capabilities have the potential to create alternative means to respond to the demand for increased throughput in the National Airspace System in the near term. In the future, the SATS technology investments create potential alternatives for addressing the nation's challenge of unmet transportation demand related to the spreading of congestion on highways and in the major airport system.

The SATS program intends to enable the adoption of three operational capabilities that are not possible in the current NAS environment: Higher Volume Operations at Non-Towered/Non-Radar Airports; Lower Landing Minimums at Minimally Equipped Landing Facilities; Flight Systems for Improved Total System Performance. To enable these operational capabilities, the program is focused on developing the key airborne technologies to support the creation and evaluation of SATS operating capabilities. Coordination with other NASA programs, particularly the Aviation Safety and Aviation Systems Capacity programs, will be maintained to ensure technologies being developed in those programs can be leveraged to support the SATS concept and facilitate success. Coordination with the ASC program is also important to ensure that a fourth operational capability, enroute procedures and systems for integrated fleet operations, is addressed to enable integration of SATS-equipped aircraft into the higher en route air traffic and controlled terminal airspace. These technologies would enable near-all-weather operations by new generations of such aircraft at virtually any landing facility in the nation.

The outcome of the five-year proof of concept includes experimental data from flight and simulation evaluations as well as analysis of the implications of technologies on transportation system decision-making. A significant part of the strategy for achieving the SATS goal is participation by the Federal Aviation Administration (FAA). A Memorandum of Agreement between NASA and the FAA will guide this participation and ensure that the technology development and proof-of-concept evaluations addresses issues associated with aircraft certification, flight standards, air traffic, and airports. It will also be the documentation that provides for sharing of resources and the conduct of joint planning and implementation. Similar memoranda will be established with state and local governments and local airport authorities, as participation by these organizations is also important for the success of SATS.

(Budget Authority in Millions of Dollars)

SATS	**PRIOR**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**TOTAL**
SMALL AIR TRANSPORT SYSTEM	0.0	0.0	9.0	15.0	20.0	20.0	5.0	0.0	69.0
TOTAL (EXCLUDES CIVIL SERVICE COST ($M)	0.0	0.0	9.0	15.0	20.0	20.0	5.0	0.0	69.0
(ESTIMATED CIVIL SERVICE FTEs	0	0	1	3	3	3	3	0	13
CIVIL SERVICE COMPENSATION ESTIMATE ($M)	0.0	0.0	0.2	0.3	0.3	0.4	0.4	0.0	1.6

International Space Station

In FY 1983, NASA received approval to enter into a preliminary definition phase of a space station. A cost target was established at that time by President Reagan; this target provided guidance to the team undertaking the definition of what capabilities a space station could have for this amount of money. Due to the uncertainty of future inflation, the target was expressed in constant 1984 dollars. The target value of $8 billion was intended to cover the costs which would be incurred to perform the preliminary definition and the development of space station hardware and ground systems. The President also directed NASA to solicit the involvement of international parties in the space station.

After three years studying numerous design concepts, a final reference design was established by NASA and our international partners--Japan, Canada, and the member nations of the European Space Agency. Prior to requesting from the Administration and Congress the authority to proceed into the development phase, NASA undertook a comprehensive cost estimate. The resultant estimate of $14.5 billion (expressed in 1984 dollars for comparison purposes) was presented to the Administration in early 1987. After consideration, the Administration directed a National Research Council (NRC) review of the reference design and the cost estimate. The NRC reported back that the space station could be built in two phases, with the second phase adding the dual keel configuration, the co-orbiting platform, servicing capabilities, and additional solar dynamic power modules. The NRC included in its estimate of $21.0-25.0 billion (1984 dollars), a number of additional cost elements: operations, marginal Shuttle flight costs, a crew rescue vehicle, civil service salaries and expenses, facilities, and provision for additional testing and backup hardware. These estimates were furnished to the Congress in mid-1987 for their review prior to action on NASA's FY 1988 appropriation.

Over each ensuing year, Congress approved continuation of the Space Station Freedom program, but reduced each year's appropriations request. On several occasions, Congress directed NASA to redesign the Station to conform not only to the reduced appropriations request in that year but also to reduced projections of future funding availability for NASA's overall budget. In early 1993, the Administration directed NASA to undertake a 90 day study of lower cost redesign options for the Space Station, and appointed an Advisory Committee on the Redesign of the Space Station. In June 1993, upon receiving the final reports and the Advisory Committee's recommendations, the Administration selected an option (A) from the three options presented and directed NASA to execute the Space Station program for no greater than $2.1 billion per year. This figure encompassed not only the development and operational costs of the Space Station itself but also the costs for a program of precursor scientific research, the expenses for integrating the Space Shuttle and the Space Station and the development of experimental facilities and capabilities for the Space Station. The cap excluded the costs of civil service salaries and expenses, Space Shuttle operational flight costs, and performance improvements to the Shuttle.

In the Fall of 1993, with the U.S. playing the lead role, the international partnership invited the Russian Government to become a participant in the program. The Russians offered access to their Mir space station in the interim period between 1995 and the beginning of the international Space Station's assembly. The Congress and Administration agreed in late 1993 that the $100 million amount to be paid annually to the Russian Space Agency for hardware and services over the FY 1994-97 period was outside the $2.1 billion annual cap. Since late 1993, the U.S. and the newly expanded set of international partners have proceeded with the final design and hardware development for an international Space Station with significantly greater capabilities for research than those which would have been provided on Space Station Freedom, or the option selected in the redesign process.

The budgetary estimates provided below include the amounts for this program in several appropriation accounts. Previous budgets provided funding for Space Station in the Human Space Flight appropriation, and through FY 1997, related research and payloads were funded in the Science, Aeronautics and Technology appropriation. In the FY 1998 budget NASA consolidated the management of Space Station research and technology, science utilization, and payload development with the Space Station development and operations program in order to enhance the integrated management of the total content of the program budget. The FY 2002 budget continues to reflect that consolidation by funding the total program budget in the International Space Station appropriation account (research budget authority will be fully transitioned back to the Office of Biological and Physical Research in the FY 2003 budget).

The Space Station project cost estimate also includes Russian Program Assurance (RPA), added in FY 1997, to fund implementation of contingency plans associated with mitigating the risks associated with potential shortfalls in planned Russian contributions. The estimate also includes funding for the X-38 project and Phase 1 of the CRV project, added to the ISS budget in FY 2000. (The CRV development and production (Phase 2) funding was shown in the outyear funding projections for Aero-Space Technology programs, in the Science, Aeronautics and Technology (SAT) appropriation account, in the FY 2001 budget runout. Those projected amounts have been redirected to the Space Station budget plan.) The FY 2002 budget proposes that the authorized funding level for the International Space Station shall not exceed $8.197 billion through FY 2006 except in amounts equal to budget reductions in other Human Space Flight programs.

The totals provide the current estimate for the costs to be incurred through the end of FY 2006. Details of the budget estimates after FY 2001 are currently under review pending an ongoing program assessment. Based on recent operational experience, continuing flight software and hardware integration issues, obsolescence issues, and realization that earlier assembly phase cost estimates were low, NASA concluded that the program baseline could not be executed on schedule within approved funding levels. A reassessment of the ISS Program budget baseline was started in FY 2000 and continued into FY 2001. The initial results, based on estimating assumptions that do not assume significant changes in cost requirements as experience is gained in operations, showed a budget shortfall of up to $4 billion over 5 fiscal years. To remain within the Agency's budget marks, the Administration directed NASA to redirect funds from remaining high-risk, high-cost hardware development, including the Habitation Module and Crew Return Vehicle (CRV), as well as funds from the RPA budget mentioned above. The intent of this direction is to ensure that ISS funding will be contained within the budget projections, while assembly continues though U.S. Core Station Complete (deployment of Node 2 on flight 10A). This will allow for the integration of flight hardware being provided by the International Partners. In addition, the ISS Research Program is being realigned to match the on-orbit capability build-up as the program moves toward U.S. Core Complete. NASA will continue to pursue atmospheric testing of the X-38 and is assessing the affordability of completing the space flight test relative to other program priorities. Options for provision of a crew return capability and Habitat capability to support the desired increase in crew size from 3 to 6 will be discussed with the international partners. However, U.S. contributions to such capabilities will be dependent on the availability of funds within the President's five-year budget plan for Human Space Flight, resolution of technical issues, and the quality of Agency cost estimates.

Over the next several years, the Agency will press ahead with ISS assembly and the integration of the partners' research modules. Research operations on board the ISS have been expanding since they began in FY 2000 and will greatly exceed any previous capabilities for research in space including Skylab, Shuttle, or Mir.

NASA will also undertake reforms and develop a plan to ensure that future Space Station costs will remain within the President's FY 2002 Budget runout. Key elements of this plan will: 1) restore cost estimating credibility, including an external review to validate cost estimates and requirements and suggest additional options as needed; 2) transfer Space Station program management reporting from the Johnson Space Center in Texas to NASA Headquarters until a new program management plan is developed and approved; and 3) open future Station hardware and service procurements to innovation and cost saving ideas through competition, including launch services and a Non-Government Organization for Space Station research.

The estimates do not include the amounts being contributed by the international partners, the initial $400 million contract with the Russian Space Agency for the Shuttle/Mir program, the costs of the non-program unique NASA facilities, Shuttle performance improvements and flight operations costs, and the general and administrative support used to execute the program. Additionally, the program is planned to achieve an average annual cost target of $1.3-1.5 billion when the Space Station becomes operationally mature.

The cost of Space Shuttle flights can be stated in two ways: marginal and annual average. The marginal cost of a given Shuttle flight ranges from $60 million to about $85 million, reflecting the reusable characteristics of the Space Shuttle. The annual average cost of an FY 2001 Shuttle flight is approximately $453 million. The nominal value contained in the NASA FY 2001 Authorization (H.R. 1654), pertaining to cost caps for the International Space Station, is $380 million per flight. Using that value for the approximately 30 Space Shuttle flights flown or planned to complete the U.S. Core Capability and accommodate international partner elements, the present cost estimate for Space Shuttle flights supporting Space Station is approximately $11.4 billion, including flights for partner elements.

Although assessment of the program is currently ongoing, NASA's preliminary evaluation is that this budget for Space Station is within the $25 billion cap established in the NASA FY 2001 Authorization (H.R. 1654), and that the Space Shuttle flights supporting the ISS are within the $17 billion cap. This is based on the assumption that the point at which substantial completion will be reached (less than 5 percent of the annual Space Station budget spent on development) will occur in FY 2004 when the U.S. Core Capability is reached. Total Space Station program funding from FY 1994 through FY 2004 is projected at $23.3 billion in this budget. Approximately 30 Shuttle flights are projected to be required to reach this point and accommodate international partner elements. Based on the $380 million per flight valuation in H.R. 1654, the value of 30 Shuttle flights is approximately $11.4 billion. When the program assessment is completed, NASA will review the program estimates pertaining to the caps.

A more detailed exposition of the program goals, objectives and activities is provided in the specific budget justification narrative for the program within the budget justifications for the Space Station.

International Space Station *

(Budget Authority in Millions of Dollars)

	PRIOR	1994-98	1999	2000	2001	2002	2003	2004	2005	2006	TOTAL
PROGRAM ELEMENTS		11,151.1	2,299.7	2,323.1	2,112.9	2,087.4	1,817.5	1,509.1	1,394.3	1,389.0	26,084.1
SPACE STATION	10,234.1	11,151.1	2,299.7	2,323.1	2,112.9	2,087.4	1,817.5	1,509.1	1,394.3	1,389.0	36,318.2
Vehicle	8,234.1	8,243.1	1,272.9	950.1	716.9						
Operations Capability	956.3	1,455.8	576.3	703.6	824.8						
Research	121.0	1,142.2	336.5	394.4	457.4						
Russian Program Assurance		310.0	114.0	200.0	24.0						
Crew Return Vehicle				75.0	89.8						
Other	922.7										
(Estimated Civil Service FTEs)			(2,136)	(2,340)	(2,396)	(2,573)	(2,398)	(2,306)	(2,302)	(2,298)	
Civil Service Compensation Estimate		652.7	177.6	210.3	228.2	255.6	251.0	255.4	259.2	272.7	

* Estimate total is through FY 2006. FY 2002 through 2006 estimates reflect appropriations language proposed in this FY 2002 budget that "…the authorized funding level for the International Space Station through fiscal year 2006 shall not exceed $8,197,300 except in amounts equal to budget reductions in other Human Space Flight programs."

- Allocation of FY 2002-2006 funding is currently under review and allocations to Vehicle, Operations, Research, RPA, CRV and final center distributions will be determined as part of program assessments
- The amounts shown have been restated to include the funds appropriated in FY 1997 and prior years to the Science, Aeronautics and Technology; Construction of Facilities; and Research and Development appropriations
- Civil Service FTE estimates for the International Space Station include research workforce at non-OSF centers

International Space Station

(Budget Authority in Millions of Dollars)

	1994-98	1999	2000	2001	2002	2003	2004	2005	2006[1]	TOTAL
FY 2001 Budget Est. – ISS	11,151.1	2,299.7	2,323.1	2,114.5	1,858.5	1,452.5	1,327.0	1,275.0	1,260.0	25,061.4
FY 2001 Budget Est. – CRV Phase 2					95.0	190.0	230.0	250.0	250.0	1,015.0
FY 2001 Budget Program Cost Estimate	**11,151.1**	**2,299.7**	**2,323.1**	**2,114.5**	**1,953.5**	**1,642.5**	**1,557.0**	**1,525.0**	**1,510.0**	**26,076.4**
FY 2002 Budget Program Cost Estimate	**11,151.1**	**2,299.7**	**2,323.1**	**2,112.9**	**2,087.4**	**1,817.5**	**1,509.1**	**1,394.3**	**1,389.0**	**26,084.1**
Change – ISS				-1.6	+228.9	+365.0	+182.1	+119.3	+129.0	+1,024.3
Change – CRV Phase 2					-95.0	-190.0	-230.0	-250.0	-250.0	-1,015.0
FY 2002 Budget Program Cost Estimate	**--**	**--**	**--**	**-1.6**	**+133.9**	**+175.0**	**-47.9**	**-130.7**	**-121.1**	**+7.7**
Operating Plans		**0**	**0**	**-1.6**						**-1.6**
Vehicle		+89	+60	+274						+423
Operations			-60	-2						-62
Research				+2						+2
Russian Program Assurance		-89		-276						-365
X-38/Crew Return Vehicle				-0						-0
Jan-01 Assessment Review					**+821**	**+1,038**	**+948**	**+731**	**+514**	**+4,052**
Propulsion module					+4	+131	+147	+129	+14	+424
HAB module					+132	+150	+135	+60	+38	+515
Avionics systems integrated lab					+17	+47	+41	+25	+18	+148
Prime development & ops					+448	+417	+358	+323	+293	+1,839
Non-Prime development & ops					+245	+278	+216	+228	+189	+1,156
Other re-estimates					-25	+15	+51	-34	-38	-30
Budget Reassessment (preliminary) *					**-687**	**-863**	**-996**	**-862**	**-635**	**-4,043**
Redirect Propulsion module funding					-118	-137	-153	-129	-14	-549
Redirect CRV Phase 2 funding					-95	-190	-230	-250	-250	-1,015
Redirect HAB module funding					-132	-150	-135	-60	-38	-515
Research realignment, content reductions, efficiencies and savings					-342	-386	-478	-423	-333	-1,964

* Reassessment is ongoing. Final reductions, allocations, & schedule impacts may adjust the details displayed here.

[1] FY 2006 funding displayed for the FY 2001 budget runout are nominal estimates, used for purposes of comparison to the FY 2002 budget runout

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 ESTIMATES

SUMMARY OF CONSULTING SERVICES

NASA uses paid experts and consultants to provide advice and expert input in addition to or beyond that available from its in-house civil service workforce. Management controls are established which assure that before entering into a consultant services arrangement with an individual that there is ample justification presented and the action is approved at top management levels.

NASA hires experts and consultants to provide expert advice and input on the selection of experiments for future space missions. The use of these experts and consultants, in addition to NASA civil service personnel, provides the agency with an independent view that assures the selection of experiments likely to have the greatest scientific merit. Other individuals are employed to provide independent looks at technical and functional problems in order to give top management the widest possible range of views before making major decisions.

	FY 2000	FY 2001	FY 2002
Number of Experts and Consultants	311	311	311
Annual FTE Usage	4	4	4
Average Annual Salary	$65,000	$68,000	$71,000
Total Salary and Benefits Costs	$283,185	$295,000	$306,000
Travel Costs	$492,000	$512,000	$532,000
Total Costs	$775,185	$807,000	$838,000

LYNDON B. JOHNSON SPACE CENTER
(JSC)

FTE Summary

	FY 00	FY 01	FY 02
TOTAL	2,929	3,036	3,021

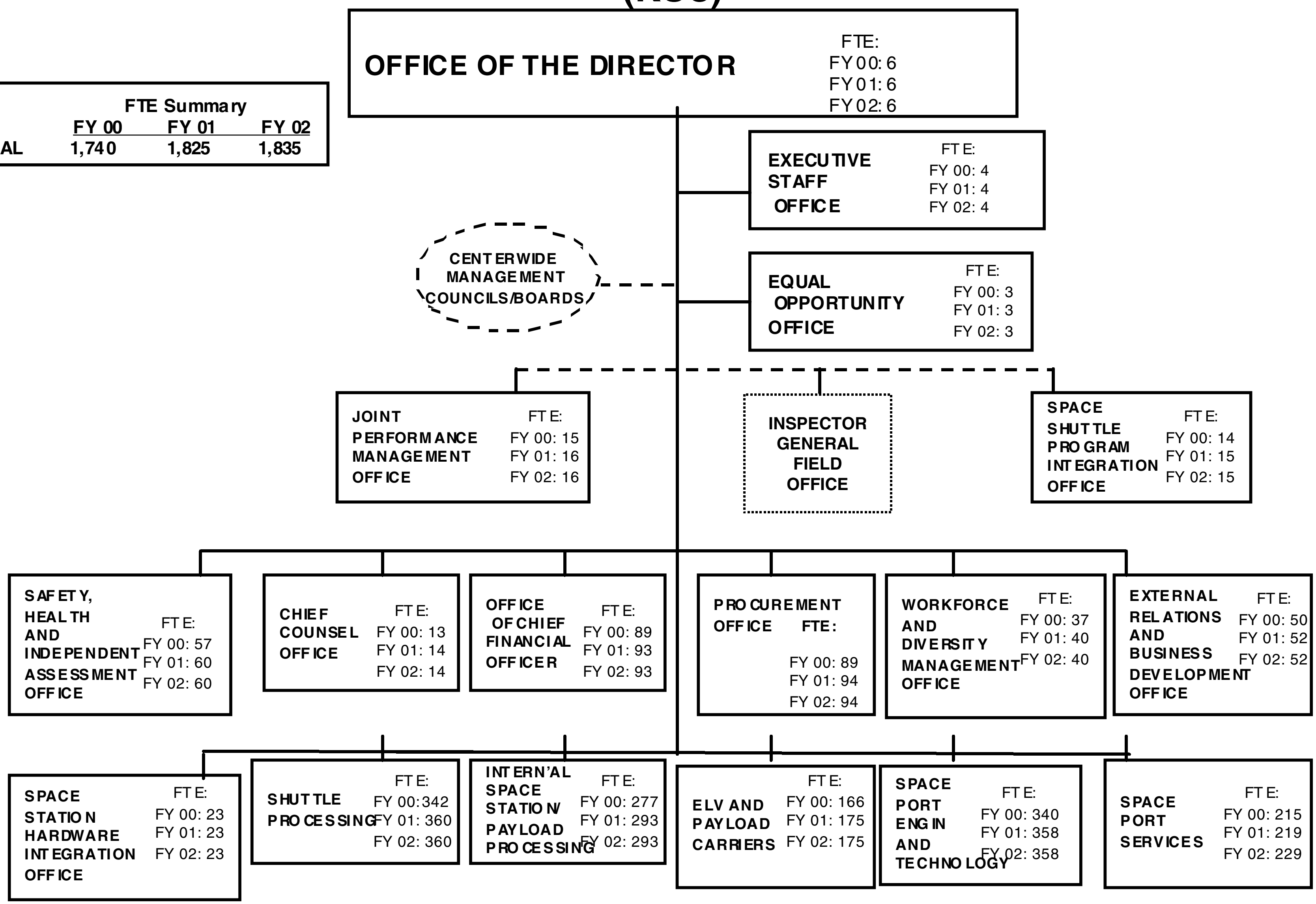
OFFICE OF THE DIRECTOR — FTE: FY 00: 17, FY 01: 21, FY 02: 21

Office	FTE: FY 00	FY 01	FY 02
HUMAN RESRCS OFFICE	52	52	52
EQUAL OPPOR. PRGRMS OFFICE	6	6	6
LEGAL OFFICE	11	12	12
PUBLIC AFFAIRS OFFICE	32	33	33
ISO 9000 OFFICE	7	7	7
OFFICE OF THE CHIEF INFOR. OFFICER	16	16	16
SAFETY, RELBLTY & QUALITY ASSURANCE OFFICE	133	133	134
OFFICE OF THE CHIEF FINANCIAL OFFICER	182	190	191
TECH. TRANSFER & COMM. OFFICE	13	13	13
SPACE STATION PRGRM OFFICE	243	280	280
SPACE SHUTTLE PRGRM OFFICE	133	144	144
SPACE OPS MGMT OFFICE	21	21	21
EVA PROJECT OFFICE	26	27	27
MISSION OPERATIONS DIRECTORATE	450	454	454
BUSINESS MANAGEMENT DIRECTORATE	133	135	136
INFORMATION SYSTEMS DIRECTORATE	87	89	89
CENTER OPERATIONS DIRECTORATE	133	167	153
ENGINEERING DIRECTORATE	815	818	818
SPACE & LIFE SCIENCES DIRECTORATE	190	186	182
FLIGHT CREW OPERATIONS DIRECTORATE	182	184	185
WHITE SANDS TEST FACILITY	47	48	47

JOHN F. KENNEDY SPACE CENTER
(KSC)

FTE Summary

	FY 00	FY 01	FY 02
TOTAL	1,740	1,825	1,835



MARSHALL SPACE FLIGHT CENTER
(MSFC)

FTE Summary	FY 00	FY 01	FY 02
TOTAL	2,576	2,758	2,785

OFFICE OF THE DIRECTOR
FTE:
FY 00: 11
FY 01: 13
FY 02: 14

SAFETY & MISSION ASSURANCE OFFICE
FTE:
FY 00: 104
FY 01: 113
FY 02: 113

PROCUREMENT OFFICE
FTE:
FY 00: 127
FY 01: 134
FY 02: 134

OFFICE OF CHIEF COUNSEL
FTE:
FY 00: 14
FY 01: 14
FY 02: 15

OFFICE OF CHIEF FINANCIAL OFFICER
FTE:
FY 00: 123
FY 01: 133
FY 02: 133

INSPECTOR GENERAL FIELD OFFICE

EQUAL OPPORTUNITY OFFICE
FTE:
FY 00: 6
FY 01: 6
FY 02: 6

SPACE SHUTTLE PROJECTS OFFICE
FTE:
FY 00: 125
FY 01: 140
FY 02: 140

SYSTEMS MANAGEMENT OFFICE
FTE:
FY 00: 22
FY 01: 25
FY 02: 25

SPACE TRANSPORTATION DIRECTORATE*
FTE:
FY 00: 426
FY 01: 471
FY 02: 472

SCIENCE DIRECTORATE
FTE:
FY 00: 342
FY 01: 351
FY 02: 351

ENGINEERING DIRECTORATE
FTE:
FY 00: 717
FY 01: 744
FY 02: 746

CUSTOMER AND EMPLOYEE RELATIONS DIRECTORATE
FTE:
FY 00: 105
FY 01: 109
FY 02: 109

FLIGHT PROJECTS DIRECTORATE
FTE:
FY 00: 277
FY 01: 302
FY 02: 302

CENTER OPERATIONS DIRECTORATE
FTE:
FY 00: 177
FY 01: 203
FY 02: 225

*Managers of Lead Center programs report to Center Director

JOHN C. STENNIS SPACE CENTER
(SSC)

FTE Summary	FY 00	FY 01	FY 02
TOTAL	272	280	300

OFFICE OF THE DIRECTOR — FTE: FY 00: 5, FY 01: 6, FY 02: 5

OFFICE OF EQUAL OPPORTUNITY — FTE: FY 00: 1, FY 01: 1, FY 02: 1

OFFICE OF THE CHIEF COUNSEL — FTE: FY 00: 4, FY 01: 4, FY 02: 4

OFFICE OF HUMAN RESOURCES — FTE: FY 00: 10, FY 01: 10, FY 02: 10

OFFICE OF THE CHIEF FINANCIAL OFFICER — FTE: FY 00: 27, FY 01: 27, FY 02: 27

OFFICE OF PUBLIC AFFAIRS — FTE: FY 00: 5, FY 01: 5, FY 02: 6

OFFICE OF EDUCATION — FTE: FY 00: 6, FY 01: 8, FY 02: 7

OFFICE OF PROCURE-MENT — FTE: FY 00: 22, FY 01: 19, FY 02: 19

OFFICE OF SAFETY AND MISSION ASSURANCE — FTE: FY 00: 15, FY 01: 17, FY 02: 18

OFFICE OF TECH TRANSFER — FTE: FY 00: 4, FY 01: 4, FY 02: 4

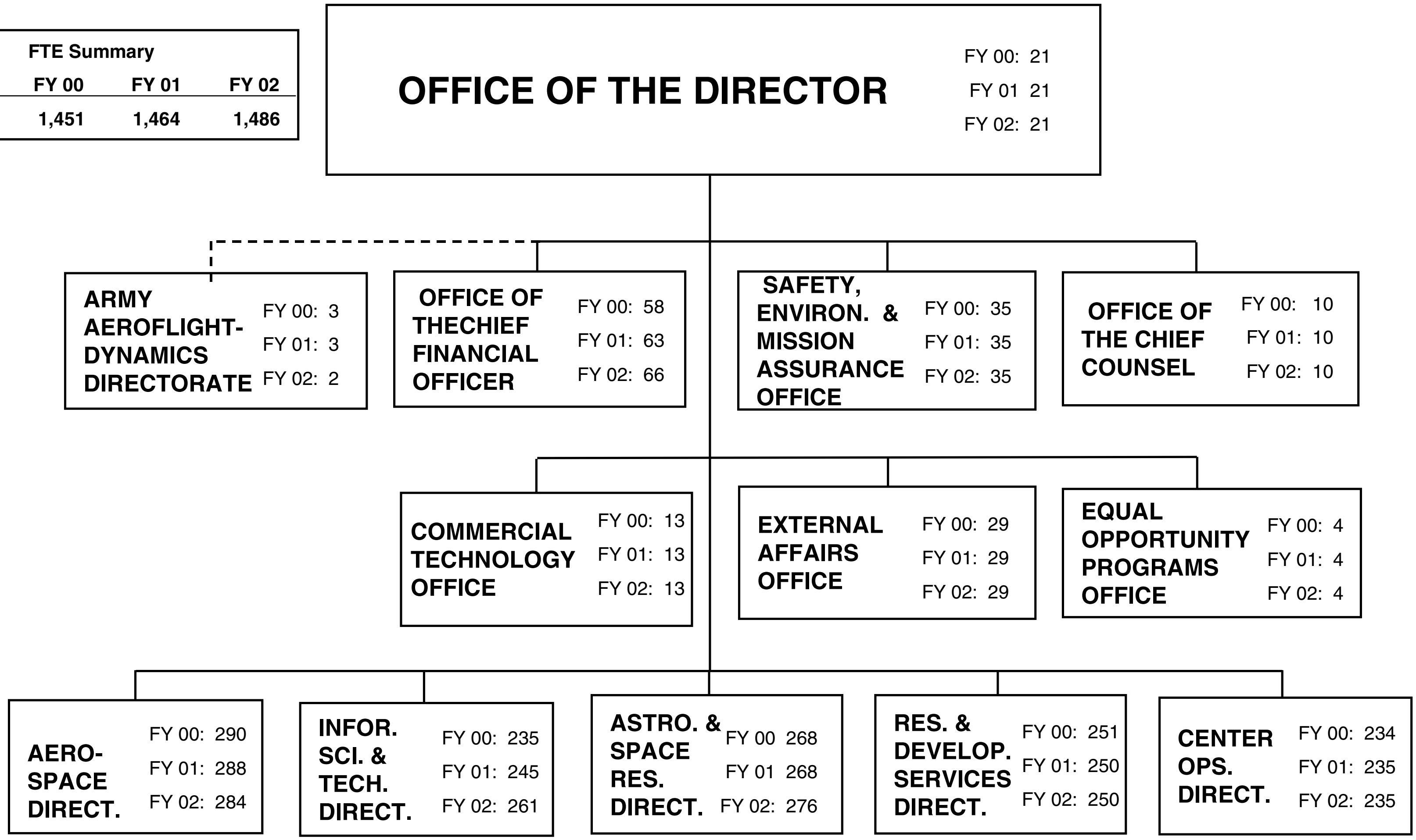
PROPULSION TEST DIRECTORATE — FTE: FY 00: 96, FY 01: 96, FY 02: 105

GEOSPACE APPLICATIONS AND DEVELOPMENT DIRECTORATE — FTE: FY 00: 28, FY 01: 30, FY 02: 30

CENTER OPERATIONS AND SUPPORT DIRECTORATE — FTE: FY 00: 49, FY 01: 53, FY 02: 64

AMES RESEARCH CENTER
(ARC)

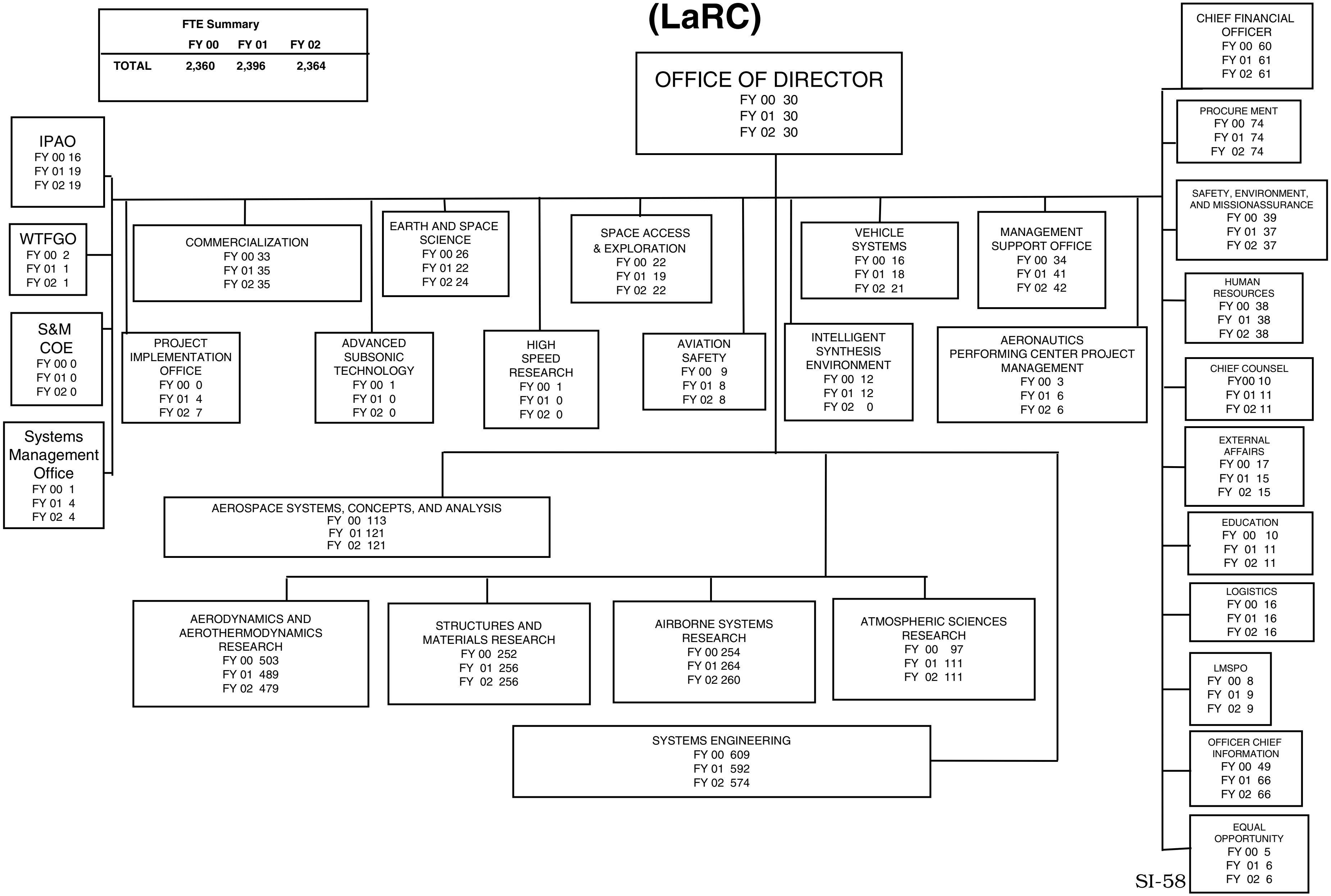
FTE Summary	FY 00	FY 01	FY 02
TOTAL	1,451	1,464	1,486



LANGLEY RESEARCH CENTER
(LaRC)

FTE Summary

	FY 00	FY 01	FY 02
TOTAL	2,360	2,396	2,364



JOHN H. GLENN RESEARCH CENTER at LEWIS FIELD
(GRC)

FTE Summary

	FY 00	FY 01	FY 02
TOTAL	1,970	1,973	1,922

OFFICE OF THE DIRECTOR — FY 00: 28; FY 01: 37; FY 02: 32

- **OFFICE OF THE CHIEF COUNSEL** — FY 00: 9; FY 01: 10; FY 02: 10
- **OFFICE OF SAFETY & MISSION ASSURANCE** — FY 00: 71; FY 01: 75; FY 02: 75

- **OFFICE OF EQUAL OPPOR. PRGRMS** — FY 00: 7; FY 01: 7; FY 02: 7
- **OFFICE OF HUMAN RESRCS** — FY 00: 67; FY 01: 68; FY 02: 68
- **OFFICE OF ACQUI-SITION** — FY 00: 97; FY 01: 96; FY 02: 96
- **SYSTEMS MANAGE-MENT OFFICE** — FY 00: 10; FY 01: 10; FY 02: 10
- **OFFICE OF THE CHIEF FINANCIAL OFFICER** — FY 00: 60; FY 01: 59; FY 02: 59

- **AERO-NAUTICS DIRECT.** — FY 00: 82; FY 01: 89; FY 02: 80
- **SPACE DIRECT.** — FY 00: 207; FY 01: 223; FY 02: 230
- **RESEARCH & TECH. DIRECT.** — FY 00: 450; FY 01: 453; FY 02: 433
- **ENG. & TECH. SERVICES DIRECT.** — FY 00: 843; FY 01: 808; FY 02: 784
- **EXTERNAL PRGRMS DIRECT.** — FY 00: 39; FY 01: 38; FY 02: 38

DRYDEN FLIGHT RESEARCH CENTER
(DFRC)

FTE Summary	FY 00	FY 01	FY02
TOTAL	617	635	609

OFFICE OF THE DIRECTOR — FY 00: 19; FY 01: 21; FY 02: 19

- **EQUAL OPPORTUNITY OFFICE** — FY 00: 2; FY 01: 3; FY 02: 3
- **HUMAN RESOURCES MGMT & DEVEL. OFFICE** — FY 00: 25; FY 01: 26; FY02: 21
- **PUBLIC AFFAIRS, COMM., & ED. OFFICE** — FY 00: 12; FY 01: 13; FY 02: 11
- **SECURITY OFFICE** — FY 00: 5; FY 01: 5; FY 02: 5
- **ACQUISITION MGMT OFFICE** — FY 00: 20; FY 01: 23; FY 02: 21
- **OFFICE OF SAFETY & MISSION ASSURANCE** — FY 00: 17; FY 01: 18; FY 02: 18
- **OFFICE OF THE CHIEF FINANCIAL OFFICER** — FY 00: 36; FY 01: 36; FY 02: 36
- **OFFICE OF THE CHIEF COUNSEL** — FY 00: 4; FY 01: 4; FY 02: 4
- **AIRBORNE SCIENCES DIRECT.** — FY 00: 13; FY 01: 15; FY 02: 14
- **RES. FACIL. DIRECT.** — FY 00: 121; FY 01: 131; FY 02: 128
- **RES. ENG. DIRECT.** — FY 00: 127; FY 01: 146; FY 02: 144
- **FLIGHT OPS. DIRECT.** — FY 00: 168; FY 01: 164; FY 02: 156
- **AEROSPACE PROJECTS DIRECT.** — FY 00: 27; FY 01: 29; FY 02: 29

GODDARD SPACE FLIGHT CENTER
(GSFC)

FTE Summary

	FY 00	FY 01	FY 02
TOTAL	3,288	3,311	3,316

Office Of The Director — FTE: FY 00: 22; FY 01: 22; FY 02: 22

	FY 00	FY 01	FY 02
Office of Equal Opportunity Programs	8	8	8
Office Of Public Affairs	30	30	30
Office Of The Chief Counsel	9	9	9
Office Of University Programs	3	3	3
Inspector General Field Office			
Office Of Human Resources	65	65	65
Office Of The Chief Financial Officer	102	93	93
Office Of Sys. Safety & Mission Assurance	64	100	105
Mgmt. Operations Direct.	580	570	570
Applied Eng. & Tech. Direct.	1178	1190	1186
Sys. Tech. & Adv. Concepts Direct.	224	220	226
Flight Programs & Projects Direct.	331	308	308
Space Sciences Direct.	243	247	243
Suborbital & Special Orb. Projects Direct.	93	98	103
Earth Sciences Direct.	336	348	345

HEADQUARTERS

FTE Summary			
	FY 00	FY 01	FY 02
TOTAL	980	1,063	1,154

OFFICE OF THE ADMINISTRATOR — FTE: FY 00: 34; FY 01: 42; FY 02: 42

INSPECTOR GENERAL (W) — FTE: FY 00: 191; FY 01: 210; FY 02: 213

AEROSPACE SAFETY ADVISORY PANEL

NASA ADVISORY COUNCIL

FUNCTIONAL OFFICES

- **CHIEF FINANCIAL OFFICER (B)** — FTE: FY 00: 55; FY 01: 58; FY 02: 67
- **GENERAL COUNSEL (G)** — FTE: FY 00: 39; FY 01: 37; FY 02: 37
- **EQUAL OPPORTUNITY PROGRAMS (E)** — FTE: FY 00: 29; FY 01: 31; FY 02: 31
- **EXTERNAL RELATIONS (I)** — FTE: FY 00: 52; FY 01: 55; FY 02: 55
- **SECURITY MANAGEMENT AND SAFEGUARDS (X)** — FTE: FY 00: 0; FY 01: 9; FY 02: 18
- **LEGISLATIVE AFFAIRS (L)** — FTE: FY 00: 28; FY 01: 28; FY 02: 28
- **HUMAN RESOURCES AND EDUCATION (F)** — FTE: FY 00: 55; FY 01: 62; FY 02: 69
- **PROCUREMENT (H) (Includes Agency Procurement Interns)** — FTE: FY 00: 51; FY 01: 64; FY 02: 74
- **PUBLIC AFFAIRS (P)** — FTE: FY 00: 49; FY 01: 48; FY 02: 48
- **POLICY & PLANS (Z)** — FTE: FY 00: 19; FY 01: 20; FY 02: 20
- **MANAGEMENT SYSTEMS AND FACILITIES (J)** — FTE: FY 00: 59; FY 01: 65; FY 02: 65
- **SAFETY AND MISSION ASSUR. (Q)** — FTE: FY 00: 40; FY 01: 44; FY 02: 44
- **HEADQUARTERS OPERATIONS (C) (Includes Students, Temps, Interns for all HQ)** — FTE: FY 00: 110; FY 01: 123; FY 02: 149
- **SMALL AND DISADVANTAGED BUSINESS UTILIZATION (K)** — FTE: FY 00: 7; FY 01: 8; FY 02: 8

PROGRAM OFFICES

- **EARTH SCIENCE (Y)*** — FTE: FY 00: 58; FY 01: 62; FY 02: 73
- **SPACE FLIGHT (M)** — FTE: FY 00: 75; FY 01: 79; FY 02: 88
- **Biological & Physical Research (U)** — FTE: FY 00: 50; FY 01: 50; FY 02: 54
- **SPACE SCIENCE (S) (Includes NMO @ JPL)** — FTE: FY 00: 103; FY 01: 109; FY 02: 115
- **AERO-SPACE TECHNOLOGY (R)** — FTE: FY 00: 67; FY 01: 69; FY 02: 69

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: NASA TOTAL

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	1,325,809	1,434,025	1,501,372
12	PERSONNEL BENEFITS (CIVIL + PCS)	289,263	306,585	323,792
13	BENEFITS TO FORMER PERSONNEL	6,949	1,325	1,086
21	TRAVEL & TRANSP OF PERSONS	49,975	53,083	54,600
22	TRANSPORTATION OF THINGS	3,355	2,231	2,011
25	OTHER SERVICES	524,393	478,126	577,638
25	OTHER SERVICES (sal/bene + tvl)	50,593	52,174	67,938
25	OTHER SERVICES (ros)*	473,800	425,952	509,700
		2,199,744	2,275,375	2,460,500

*For this exercise, ROS funding has been included in OC25 only

The Object Class Structure is a 4-digit field established to classify financial transactions by object class code for accounting and budgeting purposes. The first 2 digits will uniformy identify the classifications prescribed by the Office of Management and Budget (OMB). See OMB Circular A-12 for detailed explanation of the individual object classes.

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: JOHNSON

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	233,658	254,375	263,825
12	PERSONNEL BENEFITS (CIVIL + PCS)	49,515	52,671	56,658
13	BENEFITS TO FORMER PERSONNEL	102	300	0
21	TRAVEL & TRANSP OF PERSONS	9,056	8,958	8,750
22	TRANSPORTATION OF THINGS	828	0	0
25	OTHER SERVICES	47,095	49,716	51,653
25	OTHER SERVICES (sal/bene + tvl)	7,242	4,788	5,212
25	OTHER SERVICES (ros)*	39,853	44,928	46,441
		340,254	366,020	380,886

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: KENNEDY

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	119,911	133,569	141,171
12	PERSONNEL BENEFITS (CIVIL + PCS)	30,621	30,326	32,504
13	BENEFITS TO FORMER PERSONNEL	651	0	0
21	TRAVEL & TRANSP OF PERSONS	4,316	5,519	5,400
22	TRANSPORTATION OF THINGS	507	114	124
25	OTHER SERVICES	94,753	78,143	80,644
25	OTHER SERVICES (sal/bene + tvl)	3,080	2,494	2,800
25	OTHER SERVICES (ros)*	91,673	75,649	77,844
		250,759	247,671	259,843

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: MARSHALL

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	181,998	201,019	210,327
12	PERSONNEL BENEFITS (CIVIL + PCS)	42,671	46,152	48,009
13	BENEFITS TO FORMER PERSONNEL	4,745	0	0
21	TRAVEL & TRANSP OF PERSONS	7,259	6,330	6,300
22	TRANSPORTATION OF THINGS	660	132	134
25	OTHER SERVICES	74,888	72,997	66,240
25	OTHER SERVICES (sal/bene + tvl)	5,421	3,585	4,121
25	OTHER SERVICES (ros)*	69,467	69,412	62,119
		312,221	326,630	331,010

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: STENNIS

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	17,339	19,193	20,139
12	PERSONNEL BENEFITS (CIVIL + PCS)	4,446	4,503	4,650
13	BENEFITS TO FORMER PERSONNEL	0	0	0
21	TRAVEL & TRANSP OF PERSONS	745	758	700
22	TRANSPORTATION OF THINGS	119	99	55
25	OTHER SERVICES	21,721	19,069	22,772
25	OTHER SERVICES (sal/bene + tvl)	421	370	442
25	OTHER SERVICES (ros)*	21,300	18,699	22,330
		44,370	43,622	48,316

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: AMES

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	116,501	122,253	129,984
12	PERSONNEL BENEFITS (CIVIL + PCS)	25,061	26,298	27,961
13	BENEFITS TO FORMER PERSONNEL	800	839	893
21	TRAVEL & TRANSP OF PERSONS	3,967	3,701	3,700
22	TRANSPORTATION OF THINGS	1	1	1
25	OTHER SERVICES	35,855	38,949	37,473
25	OTHER SERVICES (sal/bene + tvl)	3,143	3,298	3,506
25	OTHER SERVICES (ros)*	32,712	35,651	33,967
		182,185	192,042	200,011

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: LANGLEY

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	159,555	170,025	176,802
12	PERSONNEL BENEFITS (CIVIL + PCS)	33,577	35,780	37,207
13	BENEFITS TO FORMER PERSONNEL	3	3	3
21	TRAVEL & TRANSP OF PERSONS	5,107	4,994	4,900
22	TRANSPORTATION OF THINGS	273	291	303
25	OTHER SERVICES	32,670	26,147	34,914
25	OTHER SERVICES (sal/bene + tvl)	4,664	4,970	5,168
25	OTHER SERVICES (ros)*	28,006	21,177	29,746
		231,185	237,240	254,129

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: GLENN

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	136,468	144,168	146,637
12	PERSONNEL BENEFITS (CIVIL + PCS)	29,133	30,777	31,158
13	BENEFITS TO FORMER PERSONNEL	25	26	28
21	TRAVEL & TRANSP OF PERSONS	3,848	3,977	3,900
22	TRANSPORTATION OF THINGS	63	67	70
25	OTHER SERVICES	30,515	31,209	33,329
25	OTHER SERVICES (sal/bene + tvl)	4,736	5,003	5,228
25	OTHER SERVICES (ros)*	25,779	26,206	28,101
		200,052	210,224	215,121

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: DRYDEN

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	42,818	45,498	46,036
12	PERSONNEL BENEFITS (CIVIL + PCS)	9,566	10,396	10,476
13	BENEFITS TO FORMER PERSONNEL	0	0	0
21	TRAVEL & TRANSP OF PERSONS	1,579	1,472	1,400
22	TRANSPORTATION OF THINGS	246	230	243
25	OTHER SERVICES	7,279	6,094	6,298
25	OTHER SERVICES (sal/bene + tvl)	731	1,324	1,398
25	OTHER SERVICES (ros)*	6,548	4,770	4,900
		61,488	63,690	64,453

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: GODDARD

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	234,446	249,165	257,876
12	PERSONNEL BENEFITS (CIVIL + PCS)	48,508	51,138	53,487
13	BENEFITS TO FORMER PERSONNEL	403	0	0
21	TRAVEL & TRANSP OF PERSONS	7,747	7,473	7,479
22	TRANSPORTATION OF THINGS	344	545	566
25	OTHER SERVICES	83,502	68,166	67,674
25	OTHER SERVICES (sal/bene + tvl)	5,674	7,042	6,444
25	OTHER SERVICES (ros)*	77,828	61,124	61,230
		374,950	376,487	387,082

*For this exercise, ROS funding has been included in OC25 only

OBJECT CLASSIFICATION (FY 2002 CONGRESSIONAL BUDGET)
(THOUSANDS OF DOLLARS)
PO/CENTER: HEADQUARTERS

(includes ROS funding to JPL)

		FY 2000	FY 2001	FY 2002
	DIRECT OBLIGATIONS			
11	PERSONNEL COMPENSATION	83,115	94,760	108,575
12	PERSONNEL BENEFITS (CIVIL + PCS)	16,165	18,543	21,683
13	BENEFITS TO FORMER PERSONNEL	220	156	162
21	TRAVEL & TRANSP OF PERSONS	6,351	9,901	12,071
22	TRANSPORTATION OF THINGS	314	753	517
25	OTHER SERVICES	96,115	87,636	176,641
25	OTHER SERVICES (sal/bene + tvl)	15,481	19,300	33,619
25	OTHER SERVICES (ros)*	80,634	68,336	143,022
		202,280	211,748	319,649

*For this exercise, ROS funding has been included in OC25 only

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 BUDGET ESTIMATES

AEROSPACE TECHNOLOGY BUDGET STRUCTURE CHANGE

NASA proposes to combine the Information Technology, Space Base NASA Research Announcements, and Special Interest Projects into the Aerospace Base Program to integrate the management of the programs, enhancing efficiency, as well as fostering synergy.

A major restructuring and replanning of the Aerospace Enterprise's Base R&T Base was accomplished during 1999 to begin the integration of the Enterprise's existing space transportation and aeronautics Base R&T development programs into a single entity.

This restructuring effort has continued, and in the latest proposed change, the Aerospace & Space Fundamental Base (formally Cross-Enterprise Technology) programs are being integrated and similar base R&T efforts consolidated. This restructuring better aligns the required technology development efforts with core competencies, reduces management overhead, and brings the expertise, resident in the aeronautics research centers, to bear on the technological challenges associated with space transportation and spacecraft systems. Secondly the integration of the space and aeronautics development needs results in a synergistic technology development plan that better utilizes our resources, eliminates duplication of effort, and allows multiple users, including the space transportation, aeronautics, and the other NASA Enterprises, to be included as part of the planning process. And finally, the character of the resultant program will become more innovative and revolutionary through the changes in the content and focus of individual activities.

FY 2001 Budget Crosswalk
(Thousands of Dollars)

FY 2002 BUDGET STRUCTURE

FY 2001 BUDGET STRUCTURE	FY 2001 OPLAN REVISED	Aerospace Base Program	Aerospace Technology Investments	Aerospace Focused Program	Commercial Technology Program
Aerospace Technology Summary	**1,404,100**	**702,846**	**11,176**	**527,636**	**162,442**
Research and Technology Base	564,750	564,750			
Aerospace Focused Programs	527,636			527,636	
High Performance Computing and Communications	22,151			22,151	
Aviation System Capacity	68,449			68,449	
Aviation Safety Technology	70,844			70,844	
Ultra-Efficient Engine Technology	47,894			47,894	
Small Aircraft Transportation System	8,980			8,980	
Quiet Aircraft Technology	19,956			19,956	
2nd Generation RLV Focused	289,362			289,362	
Aerospace Technology Investments	11,176		11,176		
Fundamental Space Base	98,184	98,184			
Space Base NASA Research Announcements	39,912	39,912			
Commercial Technology Program	162,442				162,442

FY 2002 Budget Crosswalk
(Thousands of Dollars)

FY 2002 BUDGET STRUCTURE

FY 2001 BUDGET STRUCTURE	FY 2001 OPLAN REVISED	Aerospace Base Program	Aerospace Technology Investments	Aerospace Focused Program	Commercial Technology Program
Aerospace Technology Summary	**1,504,500**	**637,000**	**--**	**720,600**	**146,900**
Research and Technology Base	506,800	506,800			
Aerospace Focused Programs	720,600			720,600	
High Performance Computing and Communications	--			--	
Aviation System Capacity	100,600			100,600	
Aviation Safety Technology	70,000			70,000	
Ultra-Efficient Engine Technology	40,000			40,000	
Small Aircraft Transportation System	15,000			15,000	
Quiet Aircraft Technology	20,000			20,000	
2nd Generation RLV Focused	475,000			475,000	
Aerospace Technology Investments	--		--		
Fundamental Space Base	90,200	90,200			
Space Base NASA Research Announcements	40,000	40,000			
Commercial Technology Program	146,900				146,900

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 2002 BUDGET ESTIMATES

SPACE OPERATIONS BUDGET STRUCTURE CHANGE

Space Operations is a new line item in the SAT budget, beginning in FY 2001. Funding for these activities is consolidated from Space Communications Services, currently part of the Mission Support account, and Mission Communication Services, currently part of the SAT account. This is being done so to link these activities more directly with the agency programs that constitute the principal users of these facilities and services. This will enable the Space Operations Management Office (SOMO) at Johnson Space Center to more effectively manage the Space Operations program. This will ensure that the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner.

The following table is a crosswalk from the current structure to the new structure for FY 2000:

FY 2000 Budget Crosswalk
(Thousands of Dollars)

		FY 2001 BUDGET STRUCTURE			
FY 2000 BUDGET STRUCTURE	FY 2000 OPLAN REVISED	Operations	Mission and Data Service Upgrades	TDRS Replenishment	Technology
Space Operations Summary	**496,000**	**326,500**	**97,600**	**31,700**	**40,200**
Mission Communications Services	**406,300**	**269,600**	**581,620**		**39,100**
Ground Networks	159,400	105,000	45,100		9,300
DSN Systems	74,700	31,700	34,300		8,700
DSN Operations	53,300	49,600	3,100		600
STDN Systems	300	300			
STDN Operations	3,600	3,600			
AB&SR Systems	6,100	500	5,600		
AB&SR Operations	21,400	19,300	2,100		
Mission Control and Data Systems	242,000	161,300	50,900		29,800
Mission Control Systems	9,700	100	9,600		
Mission Control Operations	182,700	146,400	36,300		
Data Processing Systems	41,000	8,400	2,800		29,800
Data Processing Operations	8,600	6,400	2,200		
Space Network Customer Services	4,900	3,300	1,600		
Space Communications Services	**89,700**	**56,900**		**31,700**	**1,100**
Space Network Services	4,400	4,400			
TDRS Replenishment Spacecraft	17,700			17,700	
TDRS Replenishment Launch Services	14,000			14,000	
NASA Integrated Services Network	53,600	52,500			1,100

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FY 2002 PERFORMANCE PLAN

NASA FY 2002 Performance Plan
Background and Introduction

The Government Performance and Results Act

The Government Performance and Results Act (GPRA) was passed by Congress and signed by the President in 1993. GPRA was enacted to improve the efficiency of all Federal agencies, with the following specific goals:

Improve Federal program management, effectiveness, and public accountability
Improve Congressional decisionmaking on where to commit the Nation's financial and human resources
Improve citizen confidence in Government performance

GPRA directs Executive Branch agencies to develop a customer-focused strategic plan that aligns activities with concrete missions and goals. The Act directs agencies to manage and measure results to justify Congressional appropriations and authorizations. One hundred and eighty days after the completion of the fiscal year, agencies report on the degree of success in achieving the goals and performance measures defined in the strategic and performance plans. NASA's second Annual Performance Report was furnished to the Congress in March 2001, covering the performance in FY 2000.

NASA's Strategic Management System

Processes within NASA's Strategic Management System provide the information and results for GPRA's planning and reporting requirements. This system is defined in the NASA Strategic Management Handbook (NASA Procedures and Guidelines 1000.2, February 2000). Strategic Management Elements are depicted in the handbook (Figure 1-2) illustrating the hierarchy of documentation for the Strategic Management System (Agency--Enterprise--Centers--Program/Project--Employees).

The NASA Strategic Plan (NASA Policy Directive 1000.1b) defines the vision, mission, and fundamental questions of science and research that provide the foundation of the Agency's goals. The Plan describes five Strategic Enterprises that manage the programs and activities to implement our mission, answer fundamental questions, and provide service to identified customers. These Strategic Enterprises are the: *Space Science Enterprise, Earth Science Enterprise, Human Exploration and Development of Space Enterprise, Biological and Physical Research Enterprise and Aero-Space Technology Enterprise*. The support systems for the Strategic Enterprises, defined as Crosscutting Processes, are: *Manage Strategically, Provide Aerospace Products and Capabilities, and Communicate Knowledge.* Interested readers may access NASA's Strategic Plan at the following website: http://www.hq.nasa.gov/office/codez/new/

The FY 2002 Performance Plan reflects the newly released Strategic Plan. In the NASA Strategic Plan, the vision and mission statements of the Agency are articulated. We reprint them here for the convenience of the reader.

NASA Vision Statement

NASA is an investment in America's future. As explorers, pioneers, and innovators, we boldly expand frontiers in air and space to inspire and serve America and to benefit the quality of life on Earth.

NASA Mission Statement

- ***To advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe;***
- ***To advance human exploration, use, and development of space;***
- ***To research, develop, verify, and transfer advanced aeronautics, space, and space technologies.***

Outcomes of NASA's Activities

Government investment decisions on funding for space and aeronautics research and technology cannot be made knowing in advance the full benefits ("outcomes") that will accrue from making the investments. Nor, can the timetable be known as to when these benefits will be realized. However, we can identify how the outcomes of NASA's activities contribute significantly to the achievement of America's goals in four key areas:

Economic growth and security – NASA conducts aeronautics and space research and develops technology in partnership with industry, academia, and other federal agencies to keep America capable and competitive.

Educational Excellence – NASA involves the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds.

Peaceful Exploration and Discovery – NASA explores the Universe to enrich human life by stimulating intellectual curiosity, opening new worlds of opportunity, and uniting nations of the world in this quest.

Preserving the Environment – NASA studies the Earth as a planet and as a system to understand global climate change, enabling the world to address environmental issues.

Performance targets supporting the first three outcomes can be found in all of the Enterprises and Crosscutting Processes. Performance targets supporting the preservation of the environment can be found in the Earth Science Enterprise.

NASA's Fiscal Year 2002 Budget

The NASA FY 2002 budget request supports the President's commitment to support NASA's space and aeronautics program. This budget will support the Agency's priorities as defined in the President's Blueprint for America. It will also support NASA's near – term priorities to fly the Space Shuttle safely and build the International Space Station. NASA's longer-term investments in America's future—developing more affordable, reliable means of access to space and conducting cutting-edge scientific and technological research are also supported.

The successful execution of NASA's strategic goals and objectives is contingent on receipt of the requested appropriations, as well as the provision of funds, materials, or services which have been committed to the cooperative agreements or partnerships that are referenced in this document. The parties to these agreements include: foreign governments, other Federal Agencies or Departments, and commercial entities.

Fiscal Year 2002 Estimates
(In millions of Dollars)

	FY 1999	FY 2000	*FY 2001	FY 2002
NASA Total Budget	**13,653**	**13,602**	**14,253**	**14,511**
SPACE SCIENCE	2,119	2,194	2,321	2,786
EARTH SCIENCE	1,414	1,443	1,485	1,515
HUMAN EXPLORATION AND DEVELOPMENT OF SPACE**	6,123	6,259	6,286	7,296
AEROSPACE TECHNOLOGY	1,339	1,125	1,404	2,376
BIOLOGICAL & PHYSICAL RESEARCH***				361
MISSION SUPPORT/OIG/ACADEMIC PROGRAMS	2,658	2,581	2,757	
OIG/ACADEMIC PROGRAMS				177
CIVIL SERVICE FTEs******	**18,469**	**18,375**	**18,954**	**19,005**

*Reflects 3/1/01 Operating Plan

** Includes Human Space Flight, Biological & Physical Research, Mission Communications and Space Communications Services and Space Operations. Beginning in FY02, the HEDS Enterprise includes Human Space Flight, Space Operations and Safety, Mission Assurance & Engineering.
***Beginning in FY02, Biological & Physical Research is its own Enterprise.
**** FTE's reflect total Agency including Office of Inspector General (OIG).

The mission support line in the preceding table (FY 1999 – 2001) provides funding for mission support and includes: safety, mission assurance, engineering and advanced concepts activities supporting agency program; salaries and related expenses in support of research in NASA field installations; design, repair, rehabilitation and modification of institutional facilities and construction of new institutional facilities; and other operations activities supporting conduct of agency programs such as the OIG and Academic Programs.

NASA is making progress towards full cost management. Beginning in FY 2002, NASA is implementing a two-appropriation budget (excluding the Inspector General account). The two appropriation budget includes Human Space Flight (HSF) and Science, Aeronautics and Technology (SAT). The budget for Mission Support and other select elements are being allocated against the Enterprises contained in the two appropriation budget starting in FY 2002.

For informational purposes, the Enterprise sections of this plan will display: 1) Enterprise FY funding levels for FY 1999-2002 and, 2) Civil Service staffing levels assigned to each Enterprise.

Additional detail on the means and strategies for accomplishing these performance targets is included in the budget narrative sections of this document. The NASA FY 2002 Budget is also available through the NASA homepage at the following internet address: http://ifmp.nasa.gov/codeb/budget2002/

NASA's Performance Plan

This document, as required by GPRA, describes performance measures and service levels for program activities requested in the FY 2002 budget. FY 2002 Performance goals and objectives are defined for NASA's Strategic Enterprises and for Crosscutting Processes in the *NASA Strategic Plan (NPD 1000.1b).*

NASA has instituted improvements in the FY 2002 Performance Plan. The FY 2002 Plan provides information on how NASA plans to verify and validate performance data. Enterprises/Crosscutting Processes also include a description of the individual means that they will use to verify and validate measured values in performance reporting. These added features are provided to communicate various approaches used in the verification and validation of performance data and to support the credibility of reported performance.

Strategic goals and objectives are now provided along with annual performance goals and indicators in the introductory section for each Enterprise and Crosscutting Processes. The annual performance goals and indicators used in performance tracking were integrated with the strategic goals and objectives to provide a better linkage between the Strategic Plan and the Performance Plan. In the FY 2001 Plan, annual performance goals (i.e. targets) and indicators were provided in separate Enterprise/Crosscutting Process appendix sections. NASA's new format provides greater performance context and eliminates the necessity for a separate performance table to demonstrate the linkage between the Strategic Plan and the Annual Performance Plan that was a duplicative effort.

Generate Knowledge, a crosscutting process, is not included in the FY 2002 Performance Plan based on the recommendation of the NASA Advisory Council (NAC). The NAC's recommendation was based on the potential duplication of science research metrics across the Enterprises.

In accordance with OMB Circular A-ll requirements, annual performance goals for FY 1999-2002 are displayed by Enterprise/Crosscutting Process. These multi-year formats help to demonstrate cumulative progress towards achievement of strategic goals and objectives. Each annual performance goal also has an associated color assessment to facilitate trend analysis.

The following color key is used to assess performance:

- Blue: Significantly exceeded performance
- Green: Achieved performance target
- Yellow: Did not achieve performance target, progress was significant and achievement is anticipated within next fiscal year
- Red: Failed to achieve performance target, do not anticipate completion within the next fiscal year

Each Enterprise or Crosscutting Process section continues to include a budget link table that recaps the relationship of budget account and annual performance goals. To facilitate configuration management, control numbers have been assigned to all performance targets. The numbering sequences may not be contiguous, as targets may have been dropped out as the formulation process progressed.

The Performance Evaluation Process

NASA uses a process of extensive internal and external reviews to evaluate our progress against established plans.
Enterprises and functional managers conduct reviews on a periodic basis. There are regular reviews for functional management activities, such as procurement, finance, facilities, personnel, information resources management, etc. There are reviews of science, engineering, and technology plans and performance. The NASA Inspector General conducts independent reviews and provides recommendations for corrective actions.

NASA has established management councils, as described in the NASA Strategic Management Handbook, which conduct internal oversight reviews. Throughout the year, Program Management Councils (PMCs) at Headquarters and the Centers assess program schedules, cost, and technical performance against established programmatic commitments. The Senior Management Council (SMC) brings together both Headquarters and Field Installation Directors to conduct assessment reviews twice a year of the progress being made in meeting the Enterprise and Crosscutting Process performance targets.
NASA's extant management review processes provide appropriate forums for internal reporting and reviewing of project and program performance data. The recent streamlining of agency processes provides confidence that new data collection and oversight processes need not be created for compliance with GPRA. Our mission oriented organizational structure and established management processes are well suited to assessment of this type of performance evaluation.

There are also significant external review processes in place. The external reviews typically begin with the peer review processes in which NASA uses panels of outside scientific experts to ensure that science research proposals are selected strictly on the merits of the planned research. This process takes into account past performance for selection and/or continued funding.
NASA requests assistance from other federal agencies to provide expert advice and council. In some cases, the organizations are advisory bodies of experts from the public and private sectors that work with NASA to establish priorities in particular scientific

disciplines. For example, NASA has requested that its senior advisory body, the NASA Advisory Council (NAC), independently review NASA's annual performance. Since FY 1999, the NAC has reviewed reported performance and provided a qualitative assessment of the Agency's progress that is included in the Agency Performance Report. The NAC also reviewed FY 2002 performance metrics providing valuable input for metric development. In other cases, reviews are conducted by organizations such as the NASA Advisory Council, the Aerospace Safety Advisory Panel, the National Academy of Sciences, and the General Accounting Office, which share responsibility for oversight of the Agency.

The use of these external reviews allows NASA to receive a report card on whether we are making the anticipated progress towards accomplishing the priorities established by the Administration, the Congress, and our advisory bodies. When necessary, these external assessments result in the revision of either implementation plans or strategic plans.

The GPRA Performance Evaluation and Report Process

For the purposes of the GPRA performance reporting process, NASA uses advisory committees as the critical input when assessing performance. These committees provide inputs on NASA's Strategic Plan, individual Enterprise Strategic Plans, and budgetary priorities. NASA furnishes program performance status information, and in turn, the committees render advice and council. NASA uses this process to generate an independent "scorecard" report on our annual performance.
NASA has historically been one of the most open federal agencies in terms of performance measurements. Public attention is drawn quickly to program successes, and particularly to program failures. Press conferences on scientific results and program technical status are commonplace. The technical measurement of program progress is a management imperative due to the heavy emphasis on development programs, and within the programs, the specific projects. Flight programs such as the International Space Station compile thousands of technical performance metrics, schedule milestones, and cost performance data.

However, the GPRA requires a heavier focus on outcome metrics rather than NASA's ubiquitous input and output metrics. Like other federal agencies engaged in science and technology, NASA has difficulty in quantifying outcomes and, especially, relating current outcomes to current fiscal expenditures. This is appropriate since NASA's development programs are multi-year in character. In some cases, past expenditures began more than a decade ago. For example, the Hubble Space Telescope that entered into development in the mid-1970's. More recently, NASA has focused on programs and projects with much shorter development periods, on the order of 3-5 years. Yet, the science outcomes are dependent on scientists analyzing the information gathered in the years after launch. Therefore, in measuring the incremental annual performance of a multi-year research or development activity, where an outcome is not realized for several years, output metrics are the most appropriate way to measure the progress towards the achievement of strategic goals and objectives.

The stated objectives of programs within NASA's Enterprises are long-term in character. This is exemplified by considering a Space Science performance objective, "Explore the ultimate limits of gravity and energy in the Universe." Annual performance evaluations assess whether appropriate progress is being made, perhaps actually identifying individual "limits" to the satisfaction of the scientific community, or providing additional insights to the eventual solution of other mysteries. The assessment process requires a multifaceted judgement which takes into account the nature of the challenge of "solving the mystery," the level of resources available to be applied, and the actual scientific achievements of the past year.

It is particularly important in our view to avoid evaluating actual output performance in R&D organizations solely by counting the number of planned events for the year with the number that actually occurred. The "beancount" approach is more appropriate to a known manufacturing environment. In the high-performance, high-risk R&D environment that characterizes NASA's programs, it is inadvisable to incentivize on-time performance and thereby de-emphasize safety, quality, high performance and appropriate risk-taking.

NASA has worked hard to maintain the highest emphasis on safety; this value applies not only to safety of personnel but also to preservation of high value facilities, equipment, experimental hardware, and related capabilities. Quality goes hand-in-hand with safety, but extends well beyond it. For example, taking credit for completing a critical design review (CDR) for a spacecraft is only appropriate when the CDR process has been thorough, complete, and meets performance standards. Great care must be taken that quality does not suffer when contract fee incentives call for a milestone payment upon completion of the CDR. Other examples abound, and give rise to our constant vigilance to avoid rushing to launch in order to achieve a given date.
It is possible, of course, to emphasize safety and quality and achieve little of lasting significance or have the achievement take an inordinate amount of time. Building spacecraft that do not test new designs, but rely only on proven designs, is appropriate for operational, mission agencies or commercial entities. It is not appropriate for NASA's R&D environment. Conducting basic and applied research involves experimentation. When exploring new methods and new technologies in these high-performance ventures, it is acceptable to take risks, to push the envelope, and to fail. The tolerance of failure puts NASA and other R&D agencies into a different category than other federal agencies involved in the delivery of services to the public. Note, however, that this does not translate into an acceptance of failures that result from taking an inappropriate level of risk. The level of appropriate risk is tailored to the environment. The distinction is critical, particularly in high-value, high-cost environments, such as human space flight, the maintenance of the Hubble Space Telescope, and the launch of research spacecraft. The risk of failure in those venues is limited by all practicable means.

Thus, output measures are best used in suitable context. For these reasons, NASA management encourages Space Shuttle program managers to set aside metrics dealing with launches planned vs. launches achieved during a given fiscal year. If by waiting, one less launch is achieved than planned, but the result is better safety or quality or enables improved performance or reduces risk, then the latter result is what NASA wants to incentivize.

We have met with little success in past efforts to marry conventional output measures to these other parameters to derive a quantitative performance metric. Instead, we have determined that asking independent experts to review both quantitative and qualitative measures and to come up with an integrated score is a better approach.

NASA's Verification and Validation of Performance Data

NASA is committed to ensuring that reported performance information is valid and reliable. Data credibility is a critical element in the Agency's ability to manage for results and to be accountable for the accuracy of performance data. NASA's performance in developing and delivering products and services is evaluated at the Agency, Strategic Enterprise, functional office, program and project, crosscutting process, and individual levels. Each level has responsibility to execute requirements and to measure, evaluate, and report results. Methods and procedures for collecting this information are evaluated and validated by program managers who are responsible for data collection and reporting. As each part of the organization completes its measurement process, data are used to validate that performance meets or exceeds planned goals, objectives and performance targets. In those situations in which performance does not meet expectations, opportunities for continuous improvement are identified.

Communicating our verification and validation approaches provides greater confidence that reported performance information is credible while enhancing the usefulness of the information. In the FY 2000 Performance Report, NASA provided specific documentation of achievement by providing verification and validation methods and data sources for each target. Data sources that were used included, but were not limited to, databases used for other purposes, third-party reviews, and certification by managers and/or contractors. Changes or improvements to existing data collection and reporting systems or processes were included in the verification methodology. As appropriate, reliance upon external sources were identified in the data sources section of each target's performance. With regards to external data sources, NASA relies on the individuals responsible for the performance to validate and verify the information provided for GPRA compliance. In the FY 2002 Plan, Enterprises/Crosscutting process identified verification and validation methods that it anticipates will be used to ensure the credibility of reported data.

For the purpose of assessing NASA's overall performance, we will continue to ask our Advisory Committees to evaluate accomplishments at the Enterprise level. Their assessments not only integrate quantitative output measures but also provide balance in the context of safety, quality, high performance, and appropriate risk. The NAC evaluates annual performance for both the Enterprises and the Crosscutting Processes, assessing both actual performance and progress towards strategic goal and objective achievement. In addition, the Office of the Inspector General (OIG) has conducted validation audits of reported performance data used to support the Agency's actual results on selected performance targets to ensure that underlying performance data are accurate and reliable. In their audit of select FY 2000 performance data, the OIG commended NASA for the significant improvement in the reporting of actual performance.

Space Science Enterprise (SSE)

Mission

The primary goal of the Space Science Enterprise is to chart the evolution of the universe from origins to destiny, and improve understanding of galaxies, stars, planets, and life (Figure 2). Within this goal, Enterprise objectives are to: understand the structure of the universe, from its earliest beginnings to its ultimate fate; explore the ultimate limits of gravity and energy in the universe; learn how galaxies, stars and planets form, interact, and evolve; look for signs of life in other planetary systems; understand the formation and evolution of the Solar System and Earth within it; probe the origin and evolution of life on Earth and determine if life exists elsewhere in our Solar System; understand our changing Sun and its effects throughout the Solar System; and chart our destiny in the Solar System. Other Enterprise goals include developing innovative technologies to support Space Science programs and making them available for other applications that benefit the Nation. Enterprise missions and research also yield scientific information of value for future exploration programs. Knowledge and discoveries will be shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans.

Implementation Strategy

The Space Science Enterprise Performance Plan is tied directly to the Enterprise Strategic Plan. The Strategic Plan is based on science goals and objectives, with research and flight programs structured to implement these goals. The Enterprise continues to use scientific merit as the primary criterion for program planning and resource commitment. In implementing this program, the Enterprise will preserve safety as NASA's number one priority, with balanced risks between missions to ensure overall achievement of program goals.* Properly implemented, the "faster, better, cheaper" approach does not jeopardize this priority. Projects will not be approved for implementation until a clear technology path to successful implementation is demonstrated. These new technologies will be applied aggressively, within the constraints of prudent stewardship of public investment.

The Enterprise will continue to ensure the active participation of the research community outside NASA in planning, flight programs, research investigations, and peer review; this participation is viewed as being critical to the program's success. Collaborative efforts with other Federal agencies, such as the National Science Foundation, Department of Defense and Department of Energy, as well as with international partners, play a key role in the implementation strategy of the Enterprise. Finally, a fundamental consideration in planning and conducting all of our programs is the recognition that the national investment in space science is a public trust. The Enterprise places a very high priority on sharing the results and excitement of our programs through the formal education system and public engagement.

[*Note: Safety as it applies to human space flight does not apply to Space Science missions and would be prohibitively expensive if it did. Moreover, Space Science missions should not all have the same risk profile. For example, a balance of lower-risk (e.g., Chandra) and higher-risk (e.g., Explorer) missions should be used to maximize science return per dollar.]

Enterprise Resource Requirements

The President has requested the following budget for FY99 to FY02 to support the accomplishment of Space Science goals:

	FY 1999	FY 2000	FY 2001	FY 2002
NOA $M	2119	2,194	2,321	2,786
CS FTEs	1,846	2,362	2,173	2,187

FY02 Performance Metrics

Strategic Plan Goal:
***Science:* Chart the evolution of the Universe, from origins to destiny, and understand its galaxies, stars, planets, and life.**

Objective: Understand the structure of the Universe, from its earliest beginnings to its ultimate fate.

Public Benefit: One of the great quests of the last half-millennium since the time of Copernicus has been to understand where humanity fits within the Cosmos: What is the age of the Universe? How did it begin and how will it end? What are its primary constituents and how do they interact? NASA's pursuits in the research focus areas are intended to answer these questions.

APG 2S1: Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Identify dark matter and learn how it shapes galaxies and systems of galaxies.
- Determine the size, shape, age, and energy content of the universe.

Indicators

- Demonstrate significant progress toward the goal, as determined by external expert review.
- Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Explore the ultimate limits of gravity and energy in the Universe.

Public Benefit: The basic constituents of Nature interact via fundamental forces that are likely to be studied best by using the Universe as a giant laboratory of extreme environments. Understanding these forces will give us insight into the most important processes in Nature and may reveal "new physics" and new phenomena that cannot be created in any Earthbound laboratory.

APG 2S2: Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Discover the sources of gamma ray bursts and high-energy cosmic rays.
- Test the general theory of relativity near black holes and in the early universe, and search for new physical laws, using the universe as a laboratory.
- Reveal the nature of cosmic jets and relativistic flows.

Indicators

- Demonstrate significant progress toward the goal, as determined by external expert review.
- Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Learn how galaxies, stars, and planets form, interact, and evolve.

Public Benefit: Life on Earth is the product of a complex sequence of events, which are at present only approximately understood. This sequence begins with the birth of the galaxies and continues through the creation of heavy elements inside stars and the birth of stars and other planetary systems. To understand how life arose on Earth, and perhaps elsewhere, a complete understanding of the entire "thread of life" in the Cosmos is necessary.

APG 2S3: Earn external review rating of “green” on average, on making progress in the following research focus areas:

- Observe the formation of galaxies and determine the role of gravity in this process.
- Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms.
- Observe the formation of planetary systems and characterize their properties.
- Use the exotic space environments within our Solar System as natural science laboratories and cross the outer boundary of the Solar System to explore the nearby environment of our galaxy.

Indicators

- Demonstrate significant progress toward the goal, as determined by external expert review.
- Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Look for signs of life in other planetary systems.

Public Benefit: "Are we alone?" is one of the most profound questions that humanity can ask, and its answer will affect almost every aspect of how humans view themselves and their place in the Universe.

APG 2S4: Earn external review rating of “green” on average, on making progress in the following research focus areas:

- Discover planetary systems of other stars and their physical characteristics.
- Search for worlds that could or do harbor life.

Indicators

- Demonstrate significant progress toward the goal, as determined by external expert review.
- Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Understand the formation and evolution of the Solar System and the Earth within it.

Public Benefit: Earth and all of the other bodies in the Solar System formed at about the same time from a disk of gas and dust that surrounded the Sun. While these bodies share some similarities, there are striking differences among them. A fundamental goal of the NASA Space Science Enterprise is to understand the physical conditions and processes that led to those differences.

What do these differences imply about the response of Earth's environment to natural and manmade influences? What do they imply about the likelihood of Earth-like planets, potential habitats for life, circling other stars?

APG 2S5: Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Inventory and characterize the remnants of the original material from which the Solar System formed.
- Learn why the planets in our Solar System are so different from each other.
- Learn how the Solar System evolves.

Indicators

- Demonstrate significant progress toward the goal, as determined by external expert review.
- Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Probe the evolution of life on Earth, and determine if life exists elsewhere in our Solar System.

Public Benefit: The organizing principles of life and its origin(s) are very poorly known, but at the same time are essential to understanding the biosphere, the Earth's layer of life. Understanding the origin and early evolution of life on Earth will permit a deeper understanding of the robustness (or fragility) of terrestrial life, life's interactions with the non-living world, and the dangers that life faces in an occasionally-hostile environment.

APG 2S6: Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds.
- Determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life
- Chart the distribution of life-sustaining environments within our Solar System, and search for evidence of past and present life.
- Identify plausible signatures of life on other worlds.

Indicators

- Demonstrate significant progress toward the goal, as determined by external expert review.
- Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Understand our changing Sun and its effects throughout the Solar System.

Public Benefit: Solar variability affects life and society by causing "space weather," which can affect space assets vital to the national economy (communications, weather, and military satellites), short wave radio communications, the electric power grid, and astronauts. Solar variability also is a natural driver of global climate change, which appears to have affected Earth's climate in the past.

APG 2S7: Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Understand the origins of long- and short-term solar variability.

- Understand the effects of solar variability on the solar atmosphere and heliosphere.
- Understand the space environment of Earth and other planets.

  Indicators
  - Demonstrate significant progress toward the goal, as determined by external expert review.
  - Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Chart our destiny in the Solar System.

Public Benefit: The course of life on Earth has been profoundly altered by impacts of asteroids and/or comets. It is widely accepted that a major impact 65 million years ago led to the extinction of dinosaurs and cleared the way for the rise of mammals. An even greater impact more than 200 million years ago led to the extinction of about 90 percent of the species alive at the time. Impacts did not end in prehistoric times. In 1908, a fragment of a comet or asteroid leveled hundreds of square miles of forest in the remote Siberian region of Tunguska; had the object fallen about four hours later, it would have annihilated the city of St. Petersburg. It is estimated that there are between 700 and 1000 objects whose orbits cross Earth's (these are known as Near Earth Objects, or NEOs), that are large enough to cause global catastrophe if they were to strike Earth. NASA Space Science supports the search for such NEOs, with a goal of identifying at least 90 percent of them by the year 2008 (nearly 500 have been discovered to date). By identifying those objects that actually have a potential to collide with Earth, we expect to have decades of advance warning in which to take countermeasures, if necessary.

APG 2S8: Earn external review rating of "green," on average, on making progress in the following research focus areas:

- Understand forces and processes, such as impacts, that affect habitability of Earth.
- Develop the capability to predict space weather.
- Find extraterrestrial resources and assess the suitability of Solar System locales for future human exploration.

  Indicators
  - Demonstrate significant progress toward the goal, as determined by external expert review.
  - Obtain expected scientific data from 80% of operating missions supporting this goal (as identified and documented by Associate Administrator at beginning of fiscal year).

Objective: Support of Strategic Plan Science Objectives; Development/ Near-Term Future Investments (Supports all objectives under the Science Goal)

Public Benefit: NASA has been chartered by the American people to undertake challenging scientific explorations of our Solar System and the Universe beyond by building and launching missions that will achieve ambitious scientific goals. Missions in development have moved beyond study and preliminary design, and into detailed design and fabrication. Once launched and operational, the images and data they provide will advance our understanding of our Solar System and the Universe in which we live.

APG 2S9: Earn external review rating of "green" on making progress in the following area:

- Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives.

Indicator
Meet no fewer than 75% of the development performance objectives for “major programs/projects,” supported by completion of performance objectives in majority of “other projects.”

Major Programs/Projects:

- Hubble Space Telescope (HST) Development: Begin system test of the Cosmic Origins Spectrograph (COS).
- Hubble Space Telescope (HST) Development: Advanced Camera for Surveys (ACS) and Solar Array 3 (SA3) will be ready for flight and installation on Servicing Mission 3B.
- Space Infrared Telescope Facility (SIRTF) Development: Complete integration and test (I&T) of spacecraft and payload.
- Stratospheric Observatory for Infrared Astronomy (SOFIA) Development: Complete installation of the forward pressure bulkhead.
- Gravity Probe-B (GP-B) Development: Initiate flight vehicle integration and test (I&T).
- Mars Exploration Rover ‘03 Development: Initiate assembly, test and launch operations (ATLO) process.
- Mars Reconnaissance Orbiter ’05 Development: Select payload and initiate development.
- Solar Terrestrial Relations Observatory (STEREO) Development: Have contracts in place for start of spacecraft and instrument detailed design and fabrication.

Other Projects:

- Swift Gamma Ray Burst Explorer (Swift) Development: Complete build-up of spacecraft subsystems.
- Full-sky Astrometric Mapping Explorer (FAME) Development: Conduct Confirmation Review.
- Galaxy Evolution Explorer (GALEX) Development: Complete environmental testing.
- Comet Nucleus Tour (CONTOUR) Development: Complete environmental testing.
- Mercury Surface, Space Environment, Geochemistry and Ranging (MESSENGER) Mission Development: Conduct Critical Design Review (CDR).
- Solar-B Development: Conduct the Pre-Environmental Review for the U.S.-provided Extreme Ultraviolet Imaging Spectrometer (EIS).
- Planck Development: Complete the High-Frequency Instrument (HFI) flight detectors.

Strategic Plan Goal:
Technology/Long-Term Future Investments: **Develop new technologies to enable innovative and less expensive research and flight missions.**

Objectives: Acquire new technical approaches and capabilities. Validate new technologies in space. Apply and transfer technology.

Public Benefit: NASA must be a prudent steward of the taxpayers’ money by investing in essential technologies that are clearly relevant to future missions. This important principle includes consideration of the possibilities for commercialization, as well as options for using key technologies for multiple missions.

APG 2S10: Earn external review rating of "green" on making progress in the following technology development area:

- Focus technology development on a well-defined set of performance requirements covering the needs of near-term to mid-term strategic plan missions.

  Indicator

  Meet no fewer than 66% of the performance objectives for technology development.
  - Next Generation Space Telescope (NGST): Downselect to single Phase II prime contractor.
  - Space Interferometry Mission (SIM): Use the Microarcsecond Metrology (MAM-1) Testbed to demonstrate metrology at the 200-picometer level with white light fringe measurements. (Accomplishing this level of performance is required in order for SIM to identify multi-planet solar systems out to 10 parsecs.)
  - Terrestrial Planet Finder (TPF): Provide studies and integrated models of mission architecture concepts.
  - Gamma-ray Large Area Space Telescope (GLAST): Conduct Large Area Telescope Preliminary Design Review (PDR).
  - Herschel Space Observatory: Complete the SPIRE qualification model detectors.
  - StarLight: Conduct Preliminary Design Review (PDR).
  - Outer Planets Program: Complete evaluation and restructuring of Outer Planets Program.
  - In-Space Propulsion: Compete and select Phase I award(s) for electric propulsion technology development.
  - Living With a Star: Announce instrument investigations for Solar Dynamics Observatory (SDO) mission.

Public Benefit: Careful stewardship of public money requires that challenging new technologies be evaluated via cost-effective demonstration and precursor missions so that NASA's most ambitious research facilities can be reliably developed using proven technologies.

APG 2S11: Earn external review rating of "green" on making progress in the following technology validation area:

- Formulate and implement cost-effective space demonstrations of selected technologies on suitable carriers.

  Indicator

  Meet no fewer than 66% of the performance objectives for flight validation.
  - Flight Validation/New Millennium Program: Conduct Space Technology 6 (ST-6) Confirmation Review.
  - Flight Validation/New Millennium Program: Conduct New Millennium Carrier-1 (NMC-1) Confirmation Review.
  - Flight Validation/New Millennium Program: Conduct Space Technology 5 (ST-5) Critical Design Review (CDR).

Strategic Plan Goal:

***Education and Public Outreach:* Share the excitement and knowledge generated by scientific discovery and improve science education.**

Objectives: Share the excitement of space science discoveries with the public. Enhance the quality of science, mathematics, and technology education, particularly at the pre-college level. Help create our 21st Century scientific and technical workforce.

Public Benefit: Space Science Enterprise education and public outreach goals center on sharing the results of our missions and research programs with wide audiences and using space science discoveries as vehicles to improve teaching and learning at all levels. This is a deliberate expansion of the traditional role of the Enterprise in supporting graduate and postgraduate professional education, a central element of meeting our responsibility to help create the scientific workforce of the future. Our commitment to education includes a special emphasis on pre-college education and on increasing the general public's understanding and appreciation of science, mathematics, and technology.

APG 2S12: Earn external review rating of "green," on average, on making progress in the following focus areas:

- Incorporate a substantial, funded education and outreach program into every space science flight mission and research program.
- Increase the fraction of the space science community that contributes to a broad public understanding of science and is directly involved in education at the pre-college level.
- Establish strong and lasting partnerships between the space science and education communities.
- Develop a national network to identify high-leverage education and outreach opportunities and to support long-term partnerships.
- Provide ready access to the products of space science education and outreach programs.
- Promote the participation of underserved and underutilized groups in the space science program by providing new opportunities for minorities and minority universities to compete for and participate in space science missions, research, and education programs.
- Develop tools for evaluating the quality and impact of space science education and outreach programs.

Indicator

Meet no fewer than six (75%) of the eight performance objectives for education and public outreach (E/PO).

- Ensure that every mission initiated in FY 2002 has a funded E/PO program, with a comprehensive E/PO plan prepared by its Critical Design Review (CDR).
- Ensure that by the end of FY 2002, ten percent of all research grants have an associated E/PO program underway.
- Plan and/or implement Enterprise-funded E/PO activities taking place in at least forty states.
- Ensure that at least ten Enterprise-funded research, mission development or operations, or education projects are underway in Historically Black Colleges and Universities, Hispanic Serving Institutions, and Tribal Colleges, with at least three being underway in an institution of each type.
- Provide exhibits, materials, workshops, and personnel at a minimum of five national and three regional education and outreach conferences.
- Ensure that at least eight major Enterprise-sponsored exhibits or planetarium shows will be on display or on tour at major science museums or planetariums across the country.
- Prepare the second comprehensive Space Science Education/Outreach Report describing participants, audiences, and products for Enterprise E/PO programs.
- Initiate a major external review of the accomplishments of the Space Science E/PO efforts over the past five years, and complete a pilot study directed towards the eventual development of a comprehensive approach to assessing the E/PO program's long-term effectiveness and educational impact. Use the preliminary results of both studies to guide adjustments in program direction and content.

VERIFICATION AND VALIDATION

Internal Assessment and Verification

The Space Science program consists of numerous diverse components, and each component's performance must be assessed in an appropriate way. For some program elements, such as mission and technology development, achievement of major milestones can be assessed through routine project management reviews. For missions in an operational phase, success can be gauged in terms of operating efficiency or major data sets returned. In each of these cases, performance assessment data is retrieved from normal project management reporting during the course of the fiscal year, and is verified and validated by the cognizant Program Executive or Program Scientist.

External Assessment and Verification

For the basic research programs, evaluation must consider important contextual factors such as: the relative value of the research objectives; progress toward those objectives; productivity by prevailing research community standards; and impact on related research funded or performed by other agencies. Measures such as number of grants or scientists supported, publication counts, or research citations are not able to capture these important aspects of the evaluation requirement. The best way to assess research programs has been demonstrated to be an external peer review approach. The Enterprise will employ this mechanism to qualitatively assess the progress of its programs in basic research and data analysis against Enterprise strategic plan science goals and objectives. The reviews will determine whether outcomes of these programs are fully effective, are not as strong as desired but have returned results of significant value, or are not scientifically or technologically competitive. The review process will also identify those programs that have produced important unexpected results or have contributed to an unanticipated degree to other research.

External Validation

At the conclusion of the assessment and verification process, the performance results will be reviewed and validated by the NASA Advisory Council.

MULTI-YEAR PERFORMANCE TREND

Space Science Enterprise (SSE)

Solve mysteries of the universe.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	9S1: Successfully launch seven spacecraft, within 10% of budget, on average.			
Assessment	Blue			
Annual Performance Goal and APG #	9S2: Measure the Hubble constant within an accuracy of about 10 percent, as compared to previous measurements that differ among themselves by a factor of two. (R&A)			
Assessment	Green			
Annual Performance Goal and APG #	9S3:Record 25 images and spectra at a resolution of better than an arcsecond, five to ten times sharper than images gathered earlier by the Einstein Observatory (CXO)	OS1: The Chandra X-ray Observatory (formerly AXAF) instrument will meet nominal performance expectations, and science data will be taken with 70% efficiency, with at least 90% of science data recovered on the ground.		
Assessment	Green	Green		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S4: Record data on approximately 12 compact stellar objects with a sensitivity 50 times greater than the Einstein Observatory.(CXO)			
Assessment	Green			
Annual Performance Goal and APG #	9S5: Observe physical phenomena 25,000 times closer to the event horizon of black holes than permitted with optical wavelength measurements. (RXTE)	OS2:The baseline RXTE mission ended in 1997; the target for FY00 is to operate at least three of the five instruments at an efficiency of 45%, with 95% data recovery; All Sky Monitor data will be posted on the web within 7 days, and Proportional Counter Array and High-Energy X-ray Timing Experiment data will be released within 60 days.		
Assessment	Green	Green		
Annual Performance Goal and APG #		OS3: Complete final integration and test of the Gravity Probe-B science payload with the spacecraft in August 2000.		
Assessment		Yellow		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		OS4: Successfully install and activate three key Hubble upgrades during the third servicing mission: flight computer, advanced camera, and solar arrays. Maintain an average on-target pointing efficiency of 35% during FY00 operations before they are interrupted for the third servicing mission, presently scheduled for May 2000.		
Assessment		Yellow		
Annual Performance Goal and APG #		OS43: Complete the SOFIA 747 Section 46 mockup test activity during June 2000, with no functional test discrepancies that would invalidate CDR-level designs and cause significant design rework, with attendant cost and schedule impact.		
Assessment		Green		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S5: Deliver the SIRTF Infrared Array Camera (IRAC), Multiband Imaging Photometer (MIPS), and Infrared Spectrograph (IRS) instruments during April 2000. The instruments shall perform at their specified levels at delivery.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S6: Prepare the INTEGRAL Science Data Center (ISDC) for data archiving and prepare instrument analysis software for the spectrometer on INTEGRAL (SPI) instrument within 10% of estimated cost.		
Assessment		Green		
Annual Performance Goal and APG #		0S7:Assemble and successfully test the breadboard cooler for ESA's Planck mission in April 2000.		
Assessment		Yellow		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S8: Deliver the GALEX science instrument from JPL to the Space Astrophysics Laboratory at Caltech during April 2000 for science calibration. The instrument will be fully integrated, functionally tested, and environmentally qualified at the time of the scheduled delivery.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S9: Begin system-level environmental testing of the MAP spacecraft during July 2000.		
Assessment		Green		
Annual Performance Goal and APG #		0S11:The baseline mission of the CGRO ended in 1996; the target for FY00 is to continue to operate those instruments not dependent on expended consumables (Oriented Scintillation Spectrometer Experiment, OSSE; Burst and Transient Source Experiment, BATSE; and Imaging Compton Telescope, COMPTEL) at an average efficiency of at least 60%.		
Assessment		Green		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S12: The 3-year FUSE mission will complete at least one-third of the observations needed for its minimum science program, with six of the eight instrument performance parameters being met.		
Assessment		Green		
Annual Performance Goal and APG #		0S15: The prime mission of SAMPEX ended in 1995; the FY00 target is to obtain at least 60% data coverage from at least three of SAMPEX's four instruments.		
Assessment		Green		
Annual Performance Goal and APG #		0S14: If launched, activate the XRS and XIS instruments on the Japanese Astro-E spacecraft after launch and collect at least 90% of the XRS and XIS data.		
Assessment		Red		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S53: Complete the NGST Developmental Cryogenic Active Telescope Testbed (DCATT) phase 1, measure ambient operation with off-the-shelf components, and make final preparations for phase 2, the measurement of cold telescope operation with selected "flight-like" component upgrades.		
Assessment		Red		
Annual Performance Goal and APG #		0S62: Demonstrate performance of the Superconductor-Insulator-Superconductor (SIS) mixer to at least 8hv/k at 1,120 GHz and 10hv/k at 1,200 GHz. The U.S. contribution to the ESA FIRST is the heterodyne instrument, which contains the SIS receiver.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S63: The prototype primary instrument for GLAST will demonstrate achievement of the established instrument performance level of angular resolution of 3.5 degrees across the entire 20-MeV to 100-GeV energy range.		
Assessment		Green		

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S65: Based on an overall goal of successfully launching 25 sounding rocket missions, at least 23 payloads shall successfully achieve their required altitude and orientation, and at least 21 investigators shall achieve their minimum mission success goals.		
Assessment		Red		
Annual Performance Goal and APG #		0S66: Based on an overall goal of conducting 26 worldwide science and technology demonstration balloon missions, at least 23 campaigns shall successfully achieve altitude and distance, and investigators' instrumentation shall function as planned for at least 19 missions.		
Assessment		Red		
Annual Performance Goal and APG #			1S1: Successfully develop and launch no fewer than three of four planned missions within 10% of budget and schedule. Missions are: GALEX, MAP, GP-B, and CATSAT. (Indicators have also been established for other missions in development.)	
Assessment			TBD	

Solve mysteries of the universe.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S2: Obtain expected scientific data from at least 80% of operating missions. Missions are: HST, CXO, XTE, ACE, FUSE, SWAS, and, if successfully launched, GALEX, and GP-B.	
Assessment			TBD	
Annual Performance Goal and APG #			1S3: Perform innovative scientific research and technology development by meeting technology development objectives for major projects, by achieving mission success in astronomy rocket and balloon flights, and by making satisfactory research progress in related Research and Analysis (R&A) and Data Analysis (DA) programs. Meet no fewer than 66% of the performance objectives for the following technology and research programs NGST, Herschel (FIRST), GLAST, Sounding Rockets, Balloons, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee. (#1S3)	
Assessment			TBD	

Understand the structure of the Universe, from its earliest beginnings to its ultimate fate.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2S1: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Identify dark matter and learn how it shapes galaxies and systems of galaxies. • Determine the size, shape, age, and energy content of the universe.
Assessment				TBD

Explore the ultimate limits of gravity and energy in the Universe.

Annual Performance Goal and APG #				2S2: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Discover the sources of gamma ray bursts and high-energy cosmic rays. • Test the general theory of relativity near black holes and in the early universe, and search for new physical laws using the universe as a laboratory. • Reveal the nature of cosmic jets and relativistic flows.
Assessment				TBD

Learn how galaxies, stars, and planets form, interact, and evolve.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2S3: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Observe the formation of galaxies and determine the role of gravity in this process. • Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms. • Observe the formation of planetary systems and characterize their properties. • Use the exotic space environments within our Solar System as natural science laboratories and cross the outer boundary of the Solar System to explore the nearby environment of our galaxy.
Assessment				TBD

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S6: Orbit Eros closer than 50 kilometers, 20-30 times closer than previous asteroid flybys. (NEAR)	0S16: NEAR will successfully orbit 433 Eros and meet primary scientific objectives while not exceeding projected mission cost by more than 10%.		
Assessment	Yellow	Green		
Annual Performance Goal and APG #	9S7: Measure the shape of Eros to an accuracy of 1 kilometer or better, about 10 times better than previous measurements, and measure the asteroid's mass to an accuracy of 20 percent. (NEAR)			
Assessment	Green			
Annual Performance Goal and APG #	9S8: Complete the first direct compositional measurements of an asteroid. (NEAR)			
Assessment	Yellow			
Annual Performance Goal and APG #	9S9: Map the 75 to 80 percent of the Moon's surface not accessible during the Apollo missions conducted from 1969 to 1972. (Lunar Prospector)			
Assessment	Green			

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S10:Provide definitive measurements of the weak lunar magnetic field. (Lunar Prospector)			
Assessment	Green			
Annual Performance Goal and APG #	9S11: Provide these data with spatial resolution five times better than were collected from the Yohkoh Soft X-ray Telescope. (TRACE)	0S17: Collect pixel-limited images in all Transition Region and Coronal Explorer (TRACE) wavelength bands, operating 24-hour schedules for sustained periods over eight months.		
Assessment	Green	Green		
Annual Performance Goal and APG #		0S29: Deliver the Mars '01 Orbiter and Lander science instruments that meet capability requirements by June 1, 2000; prelaunch Gamma Ray Spectrometer (GRS) tests shall determine abundances in known calibration sources to 10% accuracy.		
Assessment		Yellow		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S30: Assuming the Mars Surveyor program architecture is confirmed, meet the milestones for the Mars 03 instrument selection and initiate implementation of the Lander mission. Deliver engineering models of the radio-frequency subsystem and antennae for the radar sounder instrument to ESA (if ESA approves the Mars Express mission), and select the contractors for the major system elements of the Mars Surveyor 05 mission.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S20: The Rosetta project will deliver the electrical qualification models for the four U.S.-provided instruments to ESA in May 2000 for integration with the Rosetta Orbiter.		
Assessment		Green		
Annual Performance Goal and APG #		0S18: The TIMED mission will be delivered on time for a planned May 2000 launch, within 10% of the planned development budget.		
Assessment		Yellow		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S19:If successfully launched, the TIMED mission will acquire global data in the mesosphere and lower thermosphere/ionosphere region globally (all the latitudes) for at least 90 days at the required spatial resolution, coverage, and accuracy and for all local solar times.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S21: Complete the development of the Cluster-II instrument analysis software for the one U.S. and five U.S.-partnered instruments before launch and, if launch occurs in FY00, activate and verify the wideband data and U.S. sub-components after launch.		
Assessment		Green		
Annual Performance Goal and APG #		0S22: HESSI will be delivered in time for a planned July 2000 launch, within 10% of the planned development budget.		
Assessment		Yellow		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S23:Assuming launch and normal checkout, HESSI operations will return data to achieve at least the primary science objectives, with at least 80% coverage of the time allowed by orbit.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S25: Deliver to the Los Alamos National Laboratory in March 2000 all components for system integration and testing of the first flight system for the TWINS mission.		
Assessment		Green		
Annual Performance Goal and APG #		0S26: IMAGE will be delivered on time for a planned February 2000 launch and within 10% of the planned development budget.		
Assessment		Green		
Annual Performance Goal and APG #		0S27: If launched, IMAGE will acquire critical measurements at minute time scales, returning 85% real-time coverage of Earth's magnetospheric changes.		
Assessment		Green		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S28: Select two Small Explorer (SMEX) missions and release a University Explorer (UNEX) Announcement of Opportunity (AO).		
Assessment		Red		
Annual Performance Goal and APG #		0S24: Acquire calibrated observational data from the Japanese Yohkoh high-energy solar physics mission (including the U.S.-provided SXT) for at least 75% of the time permitted by tracking coverage.		
Assessment		Green		
Annual Performance Goal and APG #		0S31: Complete Genesis spacecraft assembly and start functional testing in November 1999.		
Assessment		Green		
Annual Performance Goal and APG #		0S32: Release an AO for the next Discovery mission.		
Assessment		Green		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S42: Successfully complete the breadboard of the imager instrument for CONTOUR and award the contract for the propulsion system after a PDR that confirms the design and maintains 15% margins for mass and power.		
Assessment		Green		
Annual Performance Goal and APG #		0S45: The baseline Galileo mission ended in 1997; the target for FY00 is to recover at least 90% of playback data from at least one Galileo flyby of Io. *(also shown below, under "Search for Life Beyond Earth")*		
Assessment		Blue		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S40: The Mars Climate Orbiter (MCO) will aerobrake from its initial insertion orbit into a near-polar, Sun-synchronous, approximately 400-km circular orbit and will initiate mapping operations no later than May 2000, acquiring 70% of the available science data and relaying to Earth 70% of the data transmitted at adequate signal levels by the Mars Polar Lander (MPL).		
Assessment		Red		
Annual Performance Goal and APG #		0S41: MPL will successfully land on Mars in December 1999 and operate its science instruments for the 80-day prime mission with at least 75% of planned science data returned.		
Assessment		Red		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S46: The Mars Global Surveyor (MGS) will acquire 70% of science data available, conduct at least two five-day atmospheric mapping campaigns, and relay to Earth at least 70% of data transmitted at adequate signal levels by the Deep Space-2 Mars microprobes. *(also shown below, under "Mars, the Moon, and small bodies")*		
Assessment		Green		
Annual Performance Goal and APG #		0S33: Collect 85% of data acquired from the International Solar-Terrestrial Physics Program (ISTP) spacecraft and successfully execute the WIND trajectory plan.		
Assessment		Green		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Cassini: Continue operations during the quiescent cruise phase without major anomalies, conduct planning for the Jupiter gravity-assist flyby, and explore early science data collection opportunities. The following in-flight activities will be completed: Instrument Checkout #2; uplink Articulation and Attitude Control Subsystem (AACS) software update with Reaction Wheel Authority capability; Command and Data Subsystem Version 8; and Saturn tour designs for selection by the Program Science Group. #OS34		
Assessment		Green		
Annual Performance Goal and APG #		0S35: Capture at least 90% of available Ulysses science data. These will be the only data observed from outside-of-the-ecliptic plane.		
Assessment		Green		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Average 12 hours of Voyager Interstellar Mission data capture per day per spacecraft to characterize the heliosphere and the heliospheric processes at work in the outer solar system as well as the transition from the solar system to interstellar space. #OS36		
Assessment		Yellow		
Annual Performance Goal and APG #		0S37: Stardust: Continue spacecraft cruise operations without major anomalies and perform interstellar dust collection for at least 36 days.		
Assessment		Green		
Annual Performance Goal and APG #		0S38: FAST will return simultaneous data from high-latitude, low-altitude magnetosphere locations in the Sun-Earth connected system through solar maximum at the required resolution and accuracy with at least 85% efficiency.		
Assessment		Green		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S39: Collect and process data from the Interplanetary Monitoring Platform (IMP-8, launched in 1973), making data from at least six instruments available within 15 months and the magnetic field and plasma data available within 2 months.		
Assessment		Green		
Annual Performance Goal and APG #		0S48: ACE will measure the composition and energy spectra of heavy nuclei in at least eight solar energetic particle events; maintain real-time solar wind data transmissions at least 90% of the time; measure the isotopic composition of a majority of the “primary” galactic cosmic ray elements from carbon to zinc; and provide browse parameters within three days for 90% of the year.		
Assessment		Green		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S47: Complete the system CDR for the New Millennium Deep Space-4 (Champollion) project before the end of FY00, including successful completion of the avionics subsystem CDR and the mechanical subsystem CDR.		
Assessment		Red		
Annual Performance Goal and APG #		0S58: The Advanced Radioactive Power Source (ARPS), which is a partnership with the Department of Energy to develop small, robust, highly efficient radioisotope power sources, will accomplish the following five objectives on time and within budget in 2000: fabricate and test 15 prototype AMTEC cells by January; complete the final design of the AMTEC cells by March; complete the final design for a 75-watt ARPS by April; begin the prototype AMTEC four-cell lifetime test by April; and begin qualification unit fabrication by September.		
Assessment		Red		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S60: Complete and deliver for testing Solar-B's four Electrical Engineering Models in September 2000.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S61: Complete STEREO Phase A studies by June 2000, including the release of an AO for investigations with specific instruments and selection of the formulation phase payload.		
Assessment		Yellow		
Annual Performance Goal and APG #		0S64: Successfully complete a preliminary design for either the Europa Orbiter or Pluto-Kuiper Express mission (whichever is planned for earlier launch) that is shown to be capable of achieving the Category 1A science objectives with adequate cost, mass, power, and other engineering margins.		
Assessment		Red		

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S70: The first engineering model (EM-1) of the X2000 First Delivery will be delivered in September 2000. Successful development includes the integration of all EM-1 hardware, the functional verification of delivered hardware and software, and the ability to support ongoing testing, hardware integration, and software verification for delivered software.		
Assessment		Red		
Annual Performance Goal and APG #			1S4: Successfully develop and launch no fewer than one of two missions within 10% of budget and schedule. Missions are: Mars Odyssey ('01 Orbiter) and Genesis. (Indicators have also been established for other projects in development.)	
Assessment			TBD	

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S5: Obtain expected scientific data from at least 80% of operating missions. Missions are: Cassini, Voyager, Ulysses, SAMPEX, FAST, TRACE, Stardust, Mars Global Surveyor, and ISTP spacecraft; also, if successfully launched, TIMED, HESSI, IMAGE, Genesis, and Mars Odyssey ('01 Orbiter).	
Assessment			TBD	

Explore the solar system.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S6: Perform innovative scientific research and technology development by meeting technology development objectives for major projects, by achieving mission success in space physics rocket and balloon flights, and by making satisfactory research progress in related R&A and DA programs. Meet no fewer than 66% of the performance objectives for the following technology and research programs Solar-B, STEREO, Solar Probe, Future Solar Terrestrial Probes, Future Deep Space Technology, CISM, X2000, Sounding Rockets, and Balloons. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.	
APG Assessment				

Understand the formation and evolution of the Solar System and the Earth within it.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2S5: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Inventory and characterize the remnants of the original material from which the Solar System formed. • Learn why the planets in our Solar System are so different from each other. • Learn how the Solar System evolves.
Assessment				TBD

Probe the evolution of life on Earth, and determine if life exists elsewhere in our Solar System.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #				2S6: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds. • Determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life • Chart the distribution of life-sustaining environments within our Solar System, and search for evidence of past and present life. • Identify plausible signatures of life on other worlds.
Assessment				TBD

Understand our changing Sun and its effects throughout the Solar System.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2S7: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Understand the origins of long- and short-term solar variability. • Understand the effects of solar variability on the solar atmosphere and heliosphere. • Understand the space environment of Earth and other planets.
Assessment				TBD

Chart our destiny in the Solar System.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2S8: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Understand forces and processes, such as impacts, that affect habitability of Earth. • Develop the capability to predict space weather. • Find extraterrestrial resources and assess the suitability of Solar System locales for future human exploration.
Assessment				

Discover planets around other stars.

Annual Performance Goal and APG #	9S12:Assemble and lab-test the interferometer beam combiner. This state-of-the-art system will approximately double observational efficiency by using a new approach to fringe detection. (Keck)	0S55: Development of the interferometer program for connecting the twin Keck 10-meter telescopes with an array of four two-meter class outrigger telescopes will be tested by detecting and tracking fringes with two test siderostats at two- and ten-micron wave		
Assessment	Green	Yellow		

Discover planets around other stars.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S52: The Space Interferometry Mission (SIM) System Testbed (STB) will demonstrate, in May 2000, that an rms optical path difference can be controlled at 1.5 nanometers, operating in an emulated on-orbit mode.		
Assessment		Green		
Annual Performance Goal and APG #		0S54: Complete and deliver a technology development plan for the Terrestrial Planet Finder (TPF) mission by June 2000. This infrared interferometer mission is projected for a 2010 launch and requires the definition of technologies that will not be developed or demonstrated by precursor missions.		
Assessment		Red		

Discover planets around other stars.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S7: Perform innovative scientific research and technology development by meeting interferometry technology development objectives and by making satisfactory research progress in related R&A programs. Meet no fewer than 66% of the performance objectives for SIM, TPF, ST-3, Keck, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.	
Assessment			TBD	

Look for signs of life in other planetary systems.

Annual Performance Goal and APG #				2S4: Earn external review rating of "green," on average, on making progress in the following research focus areas: • Discover planetary systems of other stars and their physical characteristics. • Search for worlds that could or do harbor life.
Assessment				

Search for life beyond Earth.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S13: Successfully complete and receive scientific data from at least 8 of 10 planned data-taking encounters with Europa. (Galileo)			
Assessment	Green			
Annual Performance Goal and APG #	9S14: Bring the total mapping coverage to about 1 percent of the surface at about 30-meter resolution, and multispectral coverage distributed over 50 percent of the surface at lower resolution. (Galileo)			
Assessment	Green			
Annual Performance Goal and APG #	9S17: Initiate Institute operations by linking up to 8 institutions and engaging approximately 50 investigators. (Astrobiology Institute)			
Assessment	Green			
Annual Performance Goal and APG #		0S56:The Europa Orbiter project will successfully complete a PDR in March 2000 and will begin the integration and test of the Avionics Engineering Model in July 2000.		
Assessment		Red		

Search for life beyond Earth.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S8:Perform innovative scientific research and technology development by meeting technology development objectives and by making satisfactory research progress in the related R&A program, including the Astrobiology program. Meet no fewer than two of the three performance objectives for Europa Orbiter, Astrobiology, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.	
Assessment			TBD	
Annual Performance Goal and APG #			1S14: Advance the search for life beyond Earth by successfully launching a Mars mission, by obtaining data from operational spacecraft, and by performing innovative technology development. Meet no fewer than two of the three performance objectives for Mars Odyssey ('01 Orbiter), Mars Global Surveyor, and Terrestrial Planet Finder.	
Assessment			TBD	

Investigate the composition, evolution, and resources on Mars, the Moon, and small bodies.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S15: Achieve the final science orbit. (MGS)			
Assessment	Green			
Annual Performance Goal and APG #	9S19: Measure the topography with 10-meter precision, about 100 times more accurate than previous measurements. (MGS)			
Assessment	Blue			
Annual Performance Goal and APG #	9S20: Provide high-resolution 1.5-meter imaging data, 10 times more detailed than the best imaging from the 1976 Viking mission. (MGS)			
Assessment	Green			
Annual Performance Goal and APG #	9S21: Provide the first thermal infrared spectrometry of the planet. (MGS)			
Assessment	Green			

Investigate the composition, evolution, and resources on Mars, the Moon, and small bodies.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S10: Investigate the composition, evolution, and resources of Mars, the Moon, and small bodies by successfully launching a Mars mission, by obtaining data from operational spacecraft, and by making satisfactory progress in related R&A and DA programs. Meet no fewer than 75% of the performance objectives for Mars Odyssey ('01 Orbiter), CONTOUR, Mars Global Surveyor, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.	
Assessment			TBD	

Improve the reliability of space weather forecasting.

Annual Performance Goal and APG #	9S22: Achieve complete coverage (maximum and minimum) of the solar cycle, an increase from 35 percent. (Space Physics fleet of spacecraft)	*(Refer to Space Physics spacecraft targets under "Explore the Solar System.")*		
Assessment	Green			

Improve the reliability of space weather forecasting.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S11: Develop the knowledge to improve the reliability of space weather forecasting by obtaining scientific data from three of five missions and by making satisfactory progress in related areas in R&A and DA programs. Meet no fewer than 75% of the performance objectives for R&A, ACE, SAMPEX, TRACE, ISTP, and, if successfully launched, HESSI. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.	
Assessment			TBD	

Improve the reliability of space weather forecasting.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S13: Further understanding of basic natural processes and the effects of solar variability on humans and technology. Meet no fewer than two of the three performance objectives for: Strategic Plan Development, Solar Dynamics Observatory, and Research and Data Analysis. Achieve a "fully effective' (green) overall science achievement rating from the Space Science external advisory committee.	
Assessment			TBD	
Annual Performance Goal and APG #	9S24: Demonstrate an improvement in measurement precision for optical path lengths in laser light to the 100-picometer (million-millionths of a meter) range. (Micro-Arcsecond Metrology Testbed)			
Assessment	Yellow			

Improve the reliability of space weather forecasting.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S25: Demonstrate an advanced robotic manipulator with an order of magnitude performance improvement compared to the manipulator used on Viking in 1976. (Robotic Manipulator, Mars Polar Lander)			
Assessment	Green			
Annual Performance Goal and APG #		OS49: Information Systems R&T will demonstrate the search, discovery, and fusion of multiple data products at a major science meeting. Accomplish and document the infusion of five information systems R&T efforts into flight projects or the broad research community. Space science data services shall be acknowledged as enabling for two interdisciplinary collaborations.		
Assessment		Green		

Improve the reliability of space weather forecasting.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0S50: The Remote Exploration and Experimentation element of the HPCC program will demonstrate software-implemented fault tolerance for science teams' applications on a first-generation embedded computing testbed, with the applications' sustained performance degraded by no more than 25% at fault rates characteristic of deep space and low-Earth orbit.		
Assessment		Yellow		
Annual Performance Goal and APG #		In April 2000, the Center for Integrated Space Microelectronics will deliver to the X2000 First Delivery project the first engineering model of an integrated avionics system that includes the functionality of command and data handling, attitude control, power management and distribution, and science payload interface. The system will be used on the Europa Orbiter and other missions. #OS57		
Assessment		Red		

Develop new technologies needed to carry out innovative and less costly mission and research concepts.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #			1S12: Plan, develop, and validate new technologies needed to enable future research and flight missions by achieving performance objectives in the space science core technology programs and by making progress as planned in the Flight Validation program. Meet no fewer than 66% of the performance objectives for Information Systems, High Performance Computing, Explorer Program Technology, and Flight Validation.	
Assessment			TBD	

Acquire new technical approaches and capabilities. Validate new spacecraft capabilities in space. Apply and transfer technology.

Annual Performance Goal and APG #				2S10: Earn external review rating of "green" on making progress in the following technology development area: • Focus technology development on a well-defined set of performance requirements covering the needs of near-term to mid-term strategic plan missions.
Assessment				TBD

Acquire new technical approaches and capabilities. Validate new spacecraft capabilities in space. Apply and transfer technology.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #				2S11: Earn external review rating of "green" on making progress in the following technology validation area: • Formulate and implement cost-effective space demonstrations of selected technologies on suitable carriers.
Assessment				TBD

Incorporate education and enhanced public understanding of science as integral components of space science missions and research.

Annual Performance Goal and APG #	9S26: Account for 4 percent of the 150 "most important science stories" in the annual review by *Science News*.			
Assessment	Green			
Annual Performance Goal and APG #	9S27: Account for no less than 25 percent of total contributions to the college textbook *Astronomy: From the Earth to the Universe*.			
Assessment	Green			
Annual Performance Goal and APG #	9S28: Each new Space Science Enterprise mission initiated in FY 1999 will have a funded education and outreach program.			
Assessment	Green			

Incorporate education and enhanced public understanding of science as integral components of space science missions and research.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9S29: The Space Science Enterprise will complete an organized network of contacts by the end of FY 1999 to work with educators and space scientists to formulate and implement space science education and outreach programs. This network will be available to every state in the United States.	0S67: Successful achievement of at least seven of the following eight objectives will be made. (1) Each new Space Science mission will have a funded education and outreach program. (2) By the end of FY00, 10% of all Space Science research grants will have an associated education and outreach program under way. (3) Twenty-six states will have Enterprise-funded education or outreach programs planned or underway. (4) At least five research, mission development/ operations, or education programs will have been planned/undertaken in Historically Black Colleges and Universities, Hispanic Serving Institutions, or Tribal Colleges, with at least one project underway in each group. (5) At least three national and two regional educational or outreach conferences will be supported with a significant Space Science presence. (6) At least three exhibits or planetarium shows will be		

		on display. (7) An online directory providing enhanced access to major Space Science-related products and programs will be operational by end of the fiscal year. (8) A comprehensive approach to assessing the effectiveness and impact of the Space Science education and outreach efforts will be under development, with a pilot test of the evaluation initiated.		
Assessment	Green	Green		

Make education and enhanced public understanding of science an integral part of our missions and research.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #			1S9: Continue and expand the integration of education and enhanced public understanding of science with Enterprise research and flight mission programs. Meet no fewer than 75% of the eight performance objectives for education and public outreach.	
Assessment			TBD	

Share the excitement of space science discoveries with the public. Enhance the quality of science, mathematics, and technology education, particularly at the pre-college level. Help create our 21st Century scientific and technical workforce.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2S12: Earn external review rating of "green," on average, on making progress in the following focus areas: • Incorporate a substantial, funded education and outreach program into every space science flight mission and research program. • Increase the fraction of the space science community that contributes to a broad public understanding of science and is directly involved in education at the pre-college level. • Establish strong and lasting partnerships between the space science and education communities. • Develop a national network to identify high-leverage education and outreach opportunities and to support long-term partnerships. • Provide ready access to the products of space science education and outreach programs. • Promote the participation of underserved and

				underutilized groups in the space science program by providing new opportunities for minorities and minority universities to compete for and participate in space science missions, research, and education programs. • Develop tools for evaluating the quality and impact of space science education and outreach programs.
Assessment				TBD

Multi-theme / support all objectives.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #		0S68: Conduct research and analysis.		
Assessment		Green		
Annual Performance Goal and APG #		0S69: Conduct data analysis.		
Assessment		Green		

Support of Strategic Plan Science Objectives; Development/ Near-Term Future Investments (supports all objectives under the Science goal)

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #				2S9: Earn external review rating of "green" on making progress in the following area: • Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives.
Assessment				TBD

Space Science Enterprise FY 2002	**Budget Category**	SIRTF	HST Development	GP-B	SOFIA	STEREO	Payloads	Explorers	Discovery	Mars Surveyor	Operating Missions	SR&T
Annual Performance Goal & APG #												
2S1: Earn external review rating of "green," on average, on making progress in the following research focus areas: (1) Identify dark matter and learn how it shapes galaxies and systems of galaxies. (2) Determine the size, shape, age, and energy content of the universe.											X	X
2S2: Earn external review rating of "green," on average, on making progress in the following research focus areas: (1) Discover the sources of gamma ray bursts and high energy cosmic rays. (2) Test the general theory of relativity near black holes and in the early universe, and search for new physical laws using the universe as a laboratory. (3) Reveal the nature of cosmic jets and relativistic flows.											X	X
2S3: Earn external review rating of "green," on average, on making progress in the following research focus areas: (1) Observe the formation of galaxies and determine the role of gravity in this process. (2) Establish how the evolution of a galaxy and the life cycle of stars influence the chemical composition of material available for making stars, planets, and living organisms. (3) Observe the formation of planetary systems and characterize their properties. (4) Use the exotic space environments within our Solar System as natural science laboratories and cross the outer boundary of the Solar System to explore the nearby environment of our galaxy.											X	X

Space Science Enterprise FY 2002	**Budget Category**	SIRTF	HST Development	GP-B	SOFIA	STEREO	Payloads	Explorers	Discovery	Mars Surveyor	Operating Missions	SR&T
2S4: Earn external review rating of "green," on average, on making progress in the following research focus areas: (1) Discover planetary systems of other stars and their physical characteristics. (2) Search for worlds that could or do harbor life.											X	X
2S5: Earn external review rating of "green," on average, on making progress in the following research focus areas: (1) Inventory and characterize the remnants of the original material from which the Solar System formed. (2) Learn why the planets in our Solar System are so different from each other. (3) Learn how the Solar System evolves.											X	X
2S6: Earn external review rating of "green," on average, on making progress in the following research focus areas: (1) Investigate the origin and early evolution of life on Earth, and explore the limits of life in terrestrial environments that might provide analogues for conditions on other worlds. (2) Determine the general principles governing the organization of matter into living systems and the conditions required for the emergence and maintenance of life. (3) Chart the distribution of life-sustaining environments within our Solar System, and search for evidence of past and present life. (4) Identify plausible signatures of life on other worlds.											X	X

Space Science Enterprise FY 2002	**Budget Category**	SIRTF	HST Development	GP-B	SOFIA	STEREO	Payloads	Explorers	Discovery	Mars Surveyor	Operating Missions	SR&T
2S7: Earn external review rating of “green,” on average, on making progress in the following research focus areas: (1) Understand the origins of long- and short-term solar variability. (2) Understand the effects of solar variability on the solar atmosphere and heliosphere. (3) Understand the space environment of Earth and other planets.											X	X
2S8: Earn external review rating of “green,” on average, on making progress in the following research focus areas: (1) Understand forces and processes, such as impacts, that affect habitability of Earth. (2) Develop the capability to predict space weather. (3) Find extraterrestrial resources and assess the suitability of Solar System locales for future human exploration.											X	X
2S9: Earn external review rating of “green” on making progress in the following area: Design, develop, and launch projects to support future research in pursuit of Strategic Plan science objectives.		X	X	X	X	X	X	X	X	X		
2S10: Earn external review rating of “green” on making progress in the following technology development area: Focus technology development on a well-defined set of performance requirements covering the needs of near-term to mid-term strategic plan missions.												X

Space Science Enterprise FY 2002	**Budget Category**	SIRTF	HST Development	GP-B	SOFIA	STEREO	Payloads	Explorers	Discovery	Mars Surveyor	Operating Missions	SR&T
2S11: Earn external review rating of "green" on making progress in the following technology validation area: Formulate and implement cost-effective space demonstrations of selected technologies on suitable carriers.												X
2S12: 'Earn external review rating of "green," on average, on making progress in the following focus areas: (1) Incorporate a substantial, funded education and outreach program into every space science flight mission and research program. (2) Increase the fraction of the space science community that contributes to a broad public understanding of science and is directly involved in education at the pre-college level. (3) Establish strong and lasting partnerships between the space science and education communities. (4) Develop a national network to identify high-leverage education and outreach opportunities and to support long-term partnerships. (5) Provide ready access to the products of space science education and outreach programs. (6) Promote the participation of underserved and underutilized groups in the space science program by providing new opportunities for minorities and minority universities to compete for and participate in space science missions, research, and education programs. (7) Develop tools for evaluating the quality and impact of space science education and outreach programs.		X	X	X	X	X	X	X	X	X	X	X

Earth Science Enterprise (ESE)

Mission

The mission of NASA's Earth Science Enterprise (ESE) is to develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. NASA brings to this endeavor the vantage point of space, allowing global views of Earth system change. NASA is a provider of objective scientific information, via observation, research, modeling, and applications demonstration, for use by decision-makers in both the public and private sectors. NASA has been studying the Earth from space from its beginnings as an agency. These efforts have led to our current activity of deploying the first series of Earth Observing System satellites that will concurrently observe the major interactions of the land, oceans, atmosphere, ice, and life that comprise the Earth system.

We know that natural and human-induced changes are acting on the Earth system. Natural forces include variation in the Sun's energy output, and volcanic eruptions, which spew dust into the atmosphere and scatter incoming sunlight. Human forces include deforestation, carbon emission from burning of fossil fuels, methane and soil dust production from agriculture, and ozone depletion by various industrial chemicals. Internal climate factors such as atmospheric water vapor and clouds also introduce feedbacks that serve to either dampen or enhance the strength of climate forcing. We also know the climate system exhibits considerable variability in time and space, i.e., both short and long term changes and regionally specific impacts.

NASA introduced the concept of Earth System Science. Researchers have constructed computer models to simulate the Earth system, and to explore the possible outcomes of potential changes they introduce in the models. This way of looking at the Earth as a system is a powerful means of understanding changes we see around us. That has two implications for Earth Science. First, we need to ***characterize*** (that is, identify and measure) the forces acting on the Earth system and its responses. Second, we have to peer inside the system to ***understand*** the source of internal variability: the complex interplay among components that comprise the system.

Earth system changes are global phenomena. Yet the system comprises many micro-scale processes, and the most significant manifestations are regional. Thus, studying such changes requires a global view at regionally discerning resolutions. This is where NASA comes in, bringing the unique capability to study planet Earth from the vantage point of space. By combining observations, research and modeling, we create a capability to ***predict*** Earth system change to help our partners produce better forecasts of change.

To ***characterize*** the forces acting on the Earth system and its responses, ***understand*** the source of internal variability and ***predict*** Earth system change, NASA must observe the Earth, conduct research and analysis of the data, model the data and synthesize the information into new knowledge. Where we are on this knowledge "life cycle" determines the strategy for our investment decisions.

Implementation Strategy

The ESE is pursuing a targeted research program, focused on a set of specific science questions that can be addressed effectively with NASA's capabilities. ESE formulates comprehensive research strategies that can lead to definitive scientific answers and to effective applications for the nation.

The key Earth Science research topics sponsored by NASA fall largely into three categories: forcings, responses, and the processes that link the two and provide feedback mechanisms. This conceptual approach applies in essence to all research areas of NASA's Earth Science program, although it is particularly relevant to the problem of climate change, a major Earth Science-related challenge facing our nation and the rest of the world. The ESE has articulated an overarching question and a set of strategic science questions which its observational programs, research and analysis, modeling, and advanced technology activities are directed at answering**.**

How is the Earth system changing, and what are the consequences for life on Earth?

How is the global Earth system changing?

What are the primary causes of change in the Earth system?

How does the Earth system respond to natural and human-induced changes?

What are the consequences of changes in the Earth system for human civilization?

How can we predict future changes in the Earth system?

In this and subsequent Performance Plans, NASA's annual results in Earth Science will be measured in terms of progress made toward answering these questions. Accordingly, the assessment of performance against the first strategic goal is structured in the form of key questions whose answers are provided by the ongoing mission of NASA's Earth Science program. While these questions will be answered over a period greater than a single year, the general nature of activities in FY02 focuses on completion of the first EOS series and characterization of the forces acting on the Earth system and its responses.

Earth Science is science in the national interest. NASA is pleased to play a leadership role in exploring and understanding our home, Earth. This ESE Performance Plan describes our planned accomplishments toward this great endeavor in Fiscal Year 2002. These planned accomplishments, while important and useful in their own right, are essential stepping stones on the path to answering ESE's science questions over the next decade.

Figure 1. Strategic Roadmap for the Earth Science Enterprise

NASA Earth Science Enterprise Roadmap	*Objectives*	**Through 2002 Characterize the Earth System**	**2003-2010 Understand the Earth System**	**2010-2025 and Beyond Predict Changes in the Earth System**
Science	• Understand Earth system variability • Identify & measure primary causes of change • Determine how the Earth system responds • Identify the consequences for civilization • Predict future Earth system changes	• Establish a benchmark for global rainfall • Estimate uptake of atmospheric CO2 from global measurements of the terrestrial biosphere • Provide precise global measurements of atmospheric temperature and humidity • Make global measurements of cloud properties to determine Earth's response to solar radiation • Measure global ocean winds and topography to improve accuracy and length of weather prediction and drive models of ocean impacts on climate change • Produce 3-D maps of the entire inhabited surface of the Earth	• Achieve a quantitative understanding of the global fresh water cycle • Quantify with a "high" or "moderate" degree of confidence all the principal Earth system forcing and response factors • Quantify the variation and trends in terrestrial and marine ecosystems; estimate carbon stocks in forests and oceans globally • Assess impacts of climate change on global ecosystems using interactive ecosystem-climate models • Assimilate ocean winds, topography, & surface temperature, tropospheric winds, and precipitation into climate and weather forecasting models	Demonstrate capability for: • 10 year climate forecasts • 12 month rain rate • 7 day forecast of pollution alerts • 60 day volcanic eruption prediction • 15-20 month El Nino forecasts • 5 day hurricane track forecast • 1-5 year earthquake forecast (experimental) • Assess sea-level rise and effects • Predict regional impacts of decadal climate change
Applications / Education	• Demonstrate scientific & technical capabilities into practical tools for public & private sector decisions • Stimulate public understanding of Earth science and encourage careers in science & technology	• Demonstrate applications of geospatial data to agriculture, forestry, urban & transportation planning, etc. • Expand use of commercial systems in collecting Earth system science data • Collaborate with educators to develop new curricula support materials using Earth science data and discoveries	• Enable 7-10 day weather and seasonal precipitation prediction capability; enable broad use of data in precision agriculture • Enable an effective mix of private, government, & international data sources and users • Incorporate Earth System Science into education curricula at the K-14 and university levels	• Conduct research to enable 10-14 day weather and annual precipitation prediction capability • Enable wide spread commercial supply and use of global environmental data; integration of environmental information and economic decision-making • Produce the next generation of Earth System Scientists
Technology	• Develop advanced technologies for Earth observation • Develop advanced information technologies for Earth science data • Partner with others for Earth system monitoring & prediction	• Implement satellite formation flying to improve science return; New Millennium Program to space- validate revolutionary technologies • Explore new instrument concepts for next decade missions • Employ high-performance computing to address Earth system modeling challenges • Collaborate with operational agencies in mission planning, development & utilization	• Develop and implement autonomous satellite control • Demonstrate a new generation of small, highly capable active, passive and in situ instruments • Employ distributed computing & data mining techniques for Earth system modeling • Transition advanced instruments for systematic measurements to operational systems • Develop high data rate communications and on-board data processing & storage	• Deploy cooperative satellite constellations and intelligent sensor webs • Design instruments for new scientific challenges; deploy advanced instruments to migrate selected observations from LEO & GEO to L1 and L2 • Develop a collaborative synthetic environment to facilitate understanding and enable remote use of models and results • Collaborate in an international global observing and information system; improve operational systems with new technology

Resource Requirements

(NOA, dollars in millions)

	FY1999	FY 2000	FY 2001	FY 2002
$ M	1413.8	1443.4	1484.6	1278.0
Civil Service FTE	1,365	1,907	1,750	1,679

Performance Measures

Enterprise Mission: Develop a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations.

NASA's ESE is dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment. The vantage point of space provides information about Earth's land, atmosphere, ice, oceans and biota that is obtainable in no other way. Programs of the ESE study the interactions among these components to advance the new discipline of Earth System Science. Our research results contribute to the development of sound environmental policy and economic investment decisions.

NASA's ESE also develops innovative technologies and applications of remote sensing for solving practical societal problems in agriculture and food production, natural hazard mitigation, water resources, regional planning, and national resource management in partnership with other Federal agencies, with industry, and with state and local governments. Earth Science discoveries are shared with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans. ESE combines the excitement of scientific discovery with the reward of practical contribution to the sustainability of planet Earth.

Strategic Goal (I): Observe, understand, and model the Earth system to learn how it is changing, and the consequences for life on Earth.

NASA's Earth observing and research program elements are the principal means by which global-scale questions about our home planet are posed and answered. These elements identify the variability in the Earth system, the forces responsible for change, the responses of the Earth system to changes, and the consequences and predictability of future change. Nations and industries make billions of dollars worth of investment decisions yearly that will be better informed by the information and understanding we provide.

Objective (IA): Discern and describe how the Earth is changing.

Annual Performance Goal 2Y1: Increase understanding of global precipitation, evaporation and how the cycling of water through the Earth system is changing by meeting at least 3 of 4 performance indicators.

It is important to establish a baseline for determining the existence or absence of significant trends in the water cycle, and the extent to which observed changes match predictions. Acceleration of the global water cycle could result in intensification and/or redistribution of rainfall patterns, severe storm frequency, droughts and glacial melting. Understanding of the water cycle enables prediction of freshwater availability.

- Combine analysis of global water vapor, precipitation and wind data sets to decipher variations (and possible trends) in the cycling of water through the atmosphere and their relation to Sea Surface Temperature changes.

- Analyze data from polar and geostationary satellites in a consistent fashion over at least two decades to evaluate whether the detectable moisture fluxes are increasing beyond the expected ranges of natural variability.

- Determine the time and spatial variability of the occurrence of strong convection regions, precipitation events, and areas of drought to assess whether or not there are discernable global changes in the distribution of moisture availability useful to food and fiber production and management of fresh water resources.

- Establish passive and active rainfall retrievals of zonal means to establish a calibration point for long-term data records of the World Climate Research Program, Global Precipitation Climatology Project (GPCP).

Annual Performance Goal 2Y2: Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales by meeting 2 of 2 performance indicators.

Establishing the basis for variations in the temperature and circulation of the upper ocean can be used to help assess any changes that may be affecting the Earth's weather and climate, including El Niño phenomena.

- Routine (every ten days) analysis from a data-assimilating global ocean model, using NASA satellite observations, will be used to evaluate ocean circulation changes. [http://www.ecco.ucsd.edu/]

- Sponsor research and satellite data analysis to develop and publish the trends in the duration and dynamics of the sea ice season for the Arctic and Antarctic polar sea ice covers for the period 1979-1999.

Annual Performance Goal 2Y3: Increase understanding of global ecosystems change by meeting at least 3 of 4 performance indicators.

The activity establishes the basis for short-term, seasonal and inter-annual variability of ecosystems and provides a baseline against which to evaluate future change. Measurements of seasonal, annual and inter-annual changes in ecosystems are used to estimate productivity in agriculture, forestry, fisheries and Earth's unmanaged lands and oceans.

- Merge Moderate-Resolution Imaging Spectroradiometer (MODIS) instrument and Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data to increase the global ocean color data coverage by 25% from a baseline of 17% per day.

- Test our ability to discriminate phytoplankton from other constituents in coastal waters using observations of phytoplankton fluorescence observations acquired by MODIS.

- Release first comprehensive validation of MODIS land data products using results from the South African Fire-Atmospheric Research Initiative (SAFARI 2000) field campaign and related field validation programs.

- Establish a quantitative relationship between vegetation indices time series derived from Advanced Very High-Resolution Radiometer (AVHRR) and MODIS to ensure long-term continuity and comparability of time series.

Annual Performance Goal 2Y4: Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting 2 of 2 performance indicators.

Reduction in atmospheric ozone amounts leads to an increased flux of ultraviolet radiation at the Earth's surface, with harmful effects on plant and animal life including human health.

- Provide continuity of calibrated data sets for determining long term trends in the total column and profile abundances of stratospheric ozone with sufficient precision to enable the later assessment of expected ozone recovery.

- Characterize the inter-annual variability and possible long-term evolution of stratospheric aerosol characteristics and profile abundances to assist in the interpretation of observed ozone changes and Chemistry-climate interactions. This requires a combination of consistently processed data records from ground-based, airborne, balloon-borne, and space-based measurements.

Annual Performance Goal 2Y5: Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least 3 of 4 performance indicators.

Sea level is estimated to have been rising by about 2 mm/year over the last century. Possible contributions to this change include thermal expansion of the oceans and the loss of ice from glaciers and the large ice sheets. Of these, the large ice sheets present the greatest uncertainty in terms of their contribution to sea level rise and also represent the greatest potential threat to the coastal ecosystems and infrastructure. It is therefore important to establish whether polar regions are in the process of losing mass and contributing to the current observed sea level rise.

- Submit for publication the first Greenland ice sheet accumulation rate and its inter-annual variability maps for the period 1975-98.

- Provide the first record of changes and variability in extent of Greenland ice sheet surface melt over the 21 years, 1979-1999, and submit for publication.

- Produce the first map of Antarctic ice sheet margin change, 1997-2000, covering key regions of the Antarctic coastline and submit this for publication.

- Define parameters for separating post-glacial rebound from ice mass changes based on Gravity Recovery And Climate Experiment (GRACE) and Ice, Clouds, and Land Elevation Satellite (ICESat) observations.

Annual Performance Goal 2Y6: Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes by meeting at least 3 of 4 performance indicators.

Motions of the Earth's Interior are the forcings which drive earthquakes, volcanoes and build our mountains and valleys. Knowledge, which has been building over the past decades, has led to a quantum leap in our understanding of how our planet has evolved. Through this new knowledge has come a better understanding of natural hazards and natural resource assessment. Technological by-products include better navigation (including civilian Global Positioning System (GPS)), the tracking of ocean height variability and the attendant visualization of EL Nino and related phenomena to name just a few of many applications.

- Produce first estimate of the secular (Long-Term) change of the Earth's magnetic field from continuous satellite measurements of the geomagnetic field. Estimate the long-term variation to 3 nano Tesla/yr or better which is equivalent to a change of 1 part in 20,000.

- Complete the evaluation of the Continuous Observations of the Rotation of the Earth (CORE) concept to demonstrate a nearly 300% improvement in Earth rotation precision using the new Mark IV correlator technology and an international consortium of Very Long Baseline Interferometry (VLBI) observatories.

- Complete Solar Laser Ranging 2000 (SLR2000) prototype development and begin evaluation of the performance of new SLR2000 automated satellite ranging station.

- Evaluate the ability of the real-time precision GPS positioning software to produce better than 40 cm global real-time positioning using NASA's Global GPS Network.

- Complete preliminary algorithms for mass flux estimation from temporal gravity field observations in preparation for the GRACE mission.

Objective (IB): Identify and measure the primary causes of change in the Earth system.

Annual Performance Goal 2Y7: Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least 3 of 4 performance indicators.

Solar radiation is the primary external force acting on Earth's climate. Atmospheric constituents, clouds and aerosols drive the climate system; changes in their concentration/distribution will contribute to climate change through a variety of processes.

- Provide continuity of 22 years of concentration measurements (and associated standards development) of anthropogenic and naturally occurring halogen-containing chemicals and other chemically active greenhouse gases to provide for an understanding of future changes in ozone and climate forcing.

- Use data assimilation techniques to combine Carbon Monoxide and Methane measurements from Measurements of Pollution in the Troposphere (MOPITT) with chemical transport models of the atmosphere to help characterize interannual differences in global emissions.

- Provide first comprehensive multi-instrument/multi-angle integrated data set for study of sources/sinks and distribution of tropospheric aerosols over land based on data from Total Ozone Mapping Spectrometer (TOMS), MODIS, and Multi-angle Imaging Spectroradiometer (MISR) instruments.

- Reduce the uncertainty in the retrievals of upper troposphere / lower stratosphere water vapor (from microwave soundings) by 10 – 30% through improved laboratory spectroscopic measurements of the water vapor continuum.

Annual Performance Goal 2Y8: Increase understanding about the changes in global land cover and land use and their causes by meeting at least 2 of 3 performance indicators.

Change in land cover and land use is the dominant present-day forcing of change in terrestrial and coastal ecosystems and constitutes our largest uncertainty in the global carbon budget. Understanding the human and biophysical factors that cause land cover and land use change will be essential for assessing consequences for food production, natural resources availability, and resource management as well as for predicting future global changes.

- Publish the first set of regional land cover and land use change case studies and a synthesis of their results.

- Characterize the role of land cover changes associated with natural fires in determining the carbon balance of ecosystems in at least two major regions of the boreal forests, quantify their impact on the global carbon budget, and submit the results for publication.

- Characterize the role of deforestation in the carbon balance of ecosystems of the Amazonian tropical forest, quantify the impact on the global carbon budget, and submit the results for publication.

Annual Performance Goal 2Y9: Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes by meeting at least 4 of 5 performance indicators.

This effort is leading to a better understanding of natural events/processes that transform or change the topographic surface of the Earth, and the impact of such changes on human activities. Progress toward answering this question will lead to a better understanding of the risk of natural hazards and societies vulnerability to natural disasters. By products of these activities include better topographic maps of the Earth surface. These are important to many endeavors such as airplane landing and routing, watershed assessment, and roadway planning. Risk assessment for natural hazards such as flooding, earthquakes, landslides and volcanoes is becoming increasingly important as societal resources are developed and concentrated in vulnerable areas.

- Begin 5-yr assessment of utility of completed Southern California Integrated GPS Network in understanding tectonic activities.

- Perform a new integrated earthquake risk assessment of the Los Angeles basin based on continued measurement of accumulated strain in the southern California region.

- Continue providing the Digital Elevation Models (DEM) of the Earth for scientific studies and practical applications.

- Evaluate the utility of single frequency GPS array technology for assessing volcanic deformation processes.

- Characterize and model topographic evolution processes in at least two major tectonically active regions of the world and publish results.

Objective (IC): Determine how the Earth system responds to natural and human-induced changes.

Annual Performance Goal 2Y10: Increase understanding of the effects of clouds and surface hydrologic processes on climate change by meeting at least 4 of 5 performance indicators.

It is important to establish a basis for determining the vertical distribution and optical properties of cloud particles to provide measurement-based estimates of atmospheric heating rather than relying on climatological statistics or models. Clouds are the most important factor that controls the Earth's radiation balance, which, along with evaporation and condensation of atmospheric and surface water, drives the major weather systems. Thus, determining the vertical distribution and optical properties of cloud particles will ultimately lead to better climate predictions. Soil moisture is an important land surface state variable, currently unmeasured at large spatial scales, that also affects weather and climate.

- Continue assembling and processing of satellite data needed for the multi-decadal global cloud Climatology being developed under the International Satellite Cloud Climatology Project (ISCCP). Reduce uncertainty (3-7% in monthly mean) in the current ISCCP dataset of globally observed cloud characteristics, particularly in the polar regions, by comparing it with new satellite datasets that provide new constraints on the derived quantities and with in situ ground-based and airborne measurements.

- Initiate development of the Cirrus Regional Study of Tropical Anvils and Layers (CRYSTAL) field study to determine the upper tropospheric distribution of ice particles and water vapor and associated radiation fluxes on storms and cloud systems, and on cloud generation, regeneration and dissipation mechanisms and their representation in both regional-scale and global climate models.

- Improve the determinations of radiation forcings and feedbacks, and thereby increase accuracy in our knowledge of heating and cooling of the Earth's surface and atmosphere. Continue the analysis of global measurements of the radiative properties of clouds and aerosol particles being made by MISR and Clouds and the Earth's Radiant Energy System (CERES) instruments on the Terra and Aqua spacecraft.

- Demonstrate over a variety of landscapes the capability to measure and diagnose soil moisture from airborne platforms, in preparation for a space-flight trial of soil moisture remote sensing.

- Improve the understanding and modeling of the aerosol radiative forcing of climate and its anthropogenic component (reduce current uncertainties of 0.1 to 0.05 in the aerosol column optical thickness and 1 to 0.4 in the Angstrom coefficient). Develop and validate aerosol retrieval and cloud screening algorithms, and processing of satellite data and transport model evaluations for a 20-year Climatology of aerosol optical thickness and particle size.

Annual Performance Goal 2Y11: Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle by meeting at least 4 of 5 performance indicators.

Today, Earth's ecosystems are experiencing multiple, interacting, changing environmental conditions, and it will be vitally important to understand the implications of their responses, including some that may surprise us, for sustained agriculture, forestry, and fisheries, and for the continued provision of ecosystem goods and services that are valuable to human societies. We also need to know how their responses provide feedback to the atmosphere through fluxes of water, energy, and trace gases. Most importantly, we must develop understanding of the past, present, and future role of ecosystems as sources and sinks of carbon and in regulating the global carbon cycle.

- Demonstrate the feasibility of using remote sensing imagery to identify functional groups of phytoplankton in the ocean.

- Develop a relationship between oceanic primary productivity and export of carbon to the deep-sea based on remote sensing observations and ocean biology models.

- Conduct airborne remote sensing campaign in Amazonia to evaluate measurement approaches for vegetation recovery and biomass change following forest clearing and impact of this secondary growth on removal of water from the atmosphere.

- Assemble and publish the first comprehensive regional analysis of the linkages between land-atmosphere interaction processes and the relationship between trace gas and aerosol emissions and the consequences of their deposition to the functioning of the ecosystems of southern Africa.

- Conduct diagnostic analysis of results from new carbon cycling models that improve the treatment of land use and land management and incorporate the effects of nutrient deposition as well as climate change, carbon dioxide enrichment, and land cover change to assess interrelation among these multiple factors affecting these ecosystems.

Annual Performance Goal 2Y12: Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least 4 of 6 performance indicators.

Ocean circulation patterns strongly influence regional climates, yet these are known to have exhibited variability. For example, circulation associated with the north Atlantic "conveyor" belt, including the Gulf Stream, provides for the relatively mild climate of northern Europe. Changes in such large-scale ocean circulation could significantly impact the habitability of this region.

- Diagnostic analysis of seasonal and interannual variability induced in the interior ocean based on forcing of an ocean model with three years of high resolution ocean winds (Ocean Surface Vector Winds Science Team).

- Near decade-long sea surface topography time series will be assimilated into high resolution Pacific Ocean model to elucidate the mechanisms of the Pacific Decadal Oscillation and its impact on seasonal/decadal climate variations.

- From Ocean Topography Experiment (TOPEX) time series, in situ observations of the World Ocean Data Assimilation Experiment, and assimilation of these data into ocean models, ascertain whether detectable changes in the deep ocean have occurred over the last decade.

- Submit for publication the first estimate of the inter-annual variability of Arctic Ocean seasonal ice production and heat and brine flux, from three years of Canadian Radar Satellite (RADARSAT) observations.

- Complete a preliminary review of how data assimilation techniques are currently being used to improve knowledge of the polar oceans (in particular the Arctic), through convening a workshop. Provide recommendations that outline the way forward for future application of data assimilation techniques for polar oceans research in NASA's ESE.

- Submit for publication twenty years of “Fram Strait” sea ice flux from RADARSAT and passive microwave ice motion. Sea ice flux through the Fram Strait represents export of fresh water from the Arctic Ocean, which in turn influences deep ocean circulation and climate variations.

Annual Performance Goal 2Y13: Increase understanding of stratospheric trace constituents and how they respond to change in climate and atmospheric composition by meeting 2 of 2 performance indicators.

Stratospheric composition, most importantly amounts of ultraviolet (UV)-absorbing ozone, respond to concentrations of chemically active trace gases and underlying meteorological conditions, such as temperature and wind distributions. Changing atmospheric conditions associated with global chemical change (and associated global warming) have the potential to affect the stratosphere, which can in turn affect fluxes of biologically-damaging UV radiation at the Earth's surface.

- Assess the possible impact of the increased abundances of greenhouse gases on the future evolution of Northern Hemisphere high latitude ozone concentration. Based on data from the Sage Ozone Loss and Validation Experiment (SOLVE) experiment.

- Document and submit for publication the respective variability of temperatures, ozone concentrations, and water vapor in and above the tropopause region and assess the interconnectedness of these changes through retrospective modeling and data analysis.

Annual Performance Goal 2Y14: Increase understanding of global sea level and how it is affected by climate change by meeting at least 2 of 3 performance indicators.

The polar ice sheets are a repository for about 75% of the Earth's fresh water and a reduction in their combined mass of just 1% would increase sea level by about 90 cm. Of the order of 100 million people would be at direct risk from a sea level rise of this magnitude (Intergovernmental Panel on Climate Change (IPCC), 1995) and many more would be indirectly affected through economic and other impacts. It is therefore important to establish whether the ice sheets have the potential, under climate change scenarios, to exhibit major changes in mass balance and if so, what the expected time-scale for such changes would be.

- Map the surface velocities at their outlets of at least 10 major outlet glaciers draining West Antarctica and at least 10 outlet glaciers draining East Antarctica and determine the positions where these glaciers start to float with a precision of 100 m. Submit these maps for publication.

- Compare new estimates of ice discharge of 20 or more Antarctic glaciers with interior mass accumulation to provide the first estimates of mass balance for their grounded ice catchments. Submit these estimates for publication.

- Establish a methodology for refining ice stream models based on radar sounding, surface velocity and surface topographic observations. Generate a technical report for peer review.

Annual Performance Goal 2Y15: Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least 4 of 5 performance indicators.

There is significant evidence that pollutant gases can be transported over very long distances (e.g., across the Pacific or Atlantic oceans). The global effects of atmospheric pollution (on agriculture, materials, human health, etc.) are poorly known due to inexact characterization of tropospheric transport, physics, and chemistry.

- Continue and extend the three year data record in order to build climatology of the high resolution vertical distribution of ozone in the tropics to improve the retrievals of tropospheric ozone concentrations based on the residual products from space-based observations.

- Archive and analyze data from the Transport of Chemical Evolution over the Pacific (TRACE-P) airborne mission and associated data sets to characterize the atmospheric plume from East Asia and to assess its contribution to regional and global atmospheric chemical composition.

- Estimate the tropospheric distributions of Hydroxyl (OH) and examine the consistency between inverse and assimilation models in determining global OH fields using multiple data sets; document via submission of one or more publications to peer-reviewed literature.

- Simulate changes in atmospheric composition projected over the 21st century with a coupled aerosol-chemistry-climate general circulation model including projected changes in anthropogenic emissions. This model, which will include first-time parameterization of tropospheric aerosol chemistry, will help to diagnose the climatic consequences of these emissions and the associated feedbacks on atmospheric composition.

- Estimates of the stratospheric contribution to tropospheric ozone will be made through chemical transport and Lagrangian transport models. The stratosphere-troposphere exchange included in these model calculations will be examined for its sensitivity to global warming.

Objective (ID): Identify the consequences of change in the Earth system for human civilization.

Annual Performance Goal 2Y16: Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation by meeting 2 of 2 performance indicators.

This activity establishes a basis for determining what changes will be induced by climate trends in the frequency, strength, and path of weather systems, which produce clouds and rain and replenish fresh water supplies.

- Characterize the interannual variations of deep tropical convection utilizing existing and new satellite-based datasets to understand relations between large-scale surface and atmospheric forcing and tropical forcing and submit results for publication.

- Demonstrate impact of assimilation of Tropical Rainfall Measuring Mission (TRMM) rainfall data on forecasting track and intensity of tropical storms by showing improvement in near real-time hurricane and typhoon forecasts in a variety of cases/conditions.

Annual Performance Goal 2Y17: Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity by meeting at least 2 of 3 performance indicators.

Today, land cover and land use changes are primarily due to human activities, and are most prevalent where human populations are large; thus the consequences of land cover and land use change impact our daily lives and the potential sustainability of food production, natural resource use, and environmental quality. Consequences of concern include changes in carbon sources and sinks; the loss of biodiversity; inputs of sediments, nutrients, and pollutants to coastal regions; land degradation, and increased risks to human health.

- Release a document describing the first set of regional land cover and land use change case studies and providing a synthesis of their results.

- Develop models incorporating the biophysical, socio-economic, institutional, and demographic determinants of land use and land cover change in Amazonia.

- Enable the scientific interchange of data, methods, and results through the operation of regional networks of scientists in four major regions of the world.

Annual Performance Goal 2Y18: Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions by meeting 2 of 2 performance indicators.

The consequences of global environmental change are often seen in the coastal zone. Human populations are concentrated near coastlines, and there are severe impacts on coastal communities from pollution, excess nutrients, storm-surge and sea-level rise. It will be important to understand the relative contributions of each of these factors to the overall changes in coastal regions, and especially, their effect on the resident human communities.

- Increase the coverage of space-based maps of coral reef distribution by 25% beyond current estimates using remotely sensed imagery.

- Develop an improved algorithm for retrievals of ocean color information from remotely sensed observations of turbid coastal systems (i.e. Case 2 water).

Objective (IE): Enable the prediction of future changes in the Earth system.

Annual Performance Goal 2Y19: Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling by meeting at least 2 of 3 performance indicators.

This activity contributes to improving the accuracy of short-term weather predictions and increasing the period of validity of long-range forecasts which are used by government, business, and individuals to protect lives and property and make investment decisions.

- Determine tropical mean convection structure (fraction of convective vs. stratiform rainfall) for the first time using TRMM's first three years of data and submit results for publication.

- Define the quantitative requirements for new operational sensors, including space-based tropospheric winds through participation in inter-agency Observing System Simulation Experiments (OSSE).

- Develop new analysis methods that integrate global observations from the complete suite of satellite (and conventional) weather measurements into a single, self-consistent analysis of water-related phenomena (diabatic heating by radiation and precipitation, water vapor and clouds, inference of water and energy fluxes and transports). This development provides for developing requirements for new satellite sensors and new data assimilation techniques.

Annual Performance Goal 2Y20: Increase understanding of the extent that transient climate variations can be understood and predicted by meeting at least 4 of 5 performance indicators.

This activity contributes to the ability to predict global and regional climate on seasonal-to-interannual time scales with sufficient accuracy for concerned socioeconomic interests to estimate the likely impact of climate variations, such as those associated with El Nino/La Nina, and to issue warnings and make appropriate contingency plans. NASA will endeavor to transition the results of this research to those public agencies that have operational planning and warning responsibilities and will also make the results available to concerned interests in the private sector.

- Document in the peer-reviewed literature the quantified impact of satellite altimeter observations on improving 12-month El Nino forecasts with a state-of-the-art coupled ocean-atmosphere-land model by comparing model predictions initialized with in-situ data and both with and without satellite altimeter data.

- Contribute to national seasonal forecasts by delivering ensembles of forecast products (e.g., surface temperature, precipitation, upper level winds) to Operational agencies (e.g., National Center for Environmental Prediction (NCEP), International Research Institute (IRI)). Forecasts with and without the use of satellite-based data will be used to document the impact of such remotely sensed data on forecast quality.

- Estimate and document potential predictability, based on multi-year reanalysis data and modeling, of regional climate variability in order to evaluate the relative contributions of seasonal-to-interannual and decadal climate variability on specific regions, with a focus on occurrence of major floods and droughts in North America and the Asian-Australian monsoon regions.

- Develop, implement, and document advanced cloud radiation and moist physics schemes in NASA climate models, and validate them against remotely-sensed radiation data, in order to improve overall skill of climate model simulations of the global energy and water cycles.

- Use multi-year satellite observations of lightning to assess the relationship of strong convection to interannual climate variations (e.g., El Nino and La Nina), and use as proxy data to assist in evaluating model representation of convective precipitation. Document results.

Annual Performance Goal 2Y21: Increase understanding of the extent that long-term climate trends can be assessed or predicted by meeting at least 4 of 5 performance indicators.

This activity will provide information needed to determine policies for possible mitigation of, or adaptation to, climate change. Specifically, it will provide information on the causes of recent and current climate changes and the expected magnitude and causes of future climate trends including the nature of regional climate changes. An integral part of this research is an assessment of the reliability of climate predictions and how alternative assumptions and policies affect them.

- Monitor global tropospheric and stratospheric temperatures, to validate climate model simulations, and to improve understanding of the relationship between surface and upper-air temperatures in a changing climate system. Document results.

- Quantify and document the likely contributions of different climate forcings (greenhouse gases, ozone, water vapor, solar irradiance) to observed long-term trends of the Arctic Oscillation. The Arctic Oscillation has practical significance as it affects the geographical patterns of climate variability and change in the troposphere.

- Quantify and document the degree to which the stratosphere and mesosphere need to be incorporated and resolved in climate models to realistically simulate interannual and decadal climate variability and change in the troposphere.

- Quantify and document the role of different forcings (greenhouse gases, ozone, water vapor, solar irradiance, stratospheric and tropospheric aerosols) and unforced (chaotic) variability in determining the evolution of global climate over the past 50 years, to develop confidence in quantitative model predictions of future climate change.

- Make quantitative comparisons of the ability of alternative ocean modeling treatments to simulate climate variability and change on interannual to century time scales. Document results.

Annual Performance Goal 2Y22: Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least 2 of 3 performance indicators.

A sound scientific basis is essential for informed decision making at the national and international level on environmental issues that underlie human health and well being and the health of the numerous ecosystems. Only through the integration of science and policy, as occurred effectively through the assessment process (for example the various assessment panels associated with the Montreal Protocol), can the sustainable development of our Nation be insured.

- Analyze the measured trends in atmospheric trace gas concentrations and compare with those estimated from industrial production and emission data. Analysis will be used to assess the completeness of our understanding of the atmospheric persistence and degradation of industrial chemicals as well as to examine the efficiency of current regulatory agreements and international reporting on the production and emissions of regulated chemicals.

- Conduct laboratory studies designed to assess the atmospheric fate of new industrial chemicals by characterizing the key photochemical processes responsible for their atmospheric breakdown.

- Continue the implementation of the Global Modeling Initiative (GMI) to provide metrics, benchmarks and controlled numerical experiments for model and algorithm simulations performance, which will allow the development of standards of model behavior for participation in assessment exercises.

Strategic Goal (II): Expand and accelerate the realization of economic and societal benefits from Earth science, information & technology.

Scientific data must be transformed into information products useful to non-scientists in order for the economy and society to realize the full benefit of it. Our applications and education programs are designed to achieve this end through partnerships between NASA and professional information product providers and educators. The accomplishment of the identified performance indicators will enable the user community to accomplish their day-to-day decision-making in a more effective manner resulting in either cost savings, improved timeliness or quality, or to accomplish tasks that were not previously possible with conventional means. The accomplishment of the performance indicators will enable the U.S. taxpayer to reap the potential socio-economic benefits of NASA's investment in Earth science and technology.

Objective (IIA): Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decision makers.

Annual Performance Goal 2Y23: Provide regional decision-makers with scientific and applications products and tools.

Increased application of and access to ESE's science and technology results will enable the Nation to reap significant benefits in the areas of community growth and infrastructure, disaster management, environmental assessment, and resource management. The performance indicators are aimed at measuring: (a) the identification of the most significant needs in the federal, state, local and tribal government community that can benefit from these results; (b) the development of new and advanced applications and related methods and practices in cooperation with the user community; and (c) the distribution of these results to the broader user population. The accomplishment of the identified target indicators and related application activities will enable the user community to accomplish their day-to-day decision-making in a more effective and efficient manner resulting in either cost savings, improved timeliness or quality, or in an ability to accomplish tasks that were not previously possible with conventional means. The accomplishment of the performance indicators will enable the U.S. taxpayer to reap the potential socio-economic benefits of NASA's investment in Earth science and technology.

- Conduct Program Planning and Analysis activities that result in the identification of five potential demonstration projects where user needs match NASA ESE science and technology capabilities.

- Develop two new joint demonstration projects with the user community.

Objective (IIB): Stimulate public interest in and understanding of Earth system science and encourage young scholars to consider careers in science and technology.

Annual Performance Goal 2Y24: Share NASA's discoveries in Earth science with the public to enhance understanding of science and technology.

Increased public awareness and understanding of how the Earth functions as a system and increased literacy in Earth science and technology will result in quality teaching and learning about the Earth and its environment, and build capacity for productive use of Earth science information in resolving everyday practical problems. Success will equate to meeting 3 of 4 performance indicators.

- Release at least 50 "stories" per year that cover scientific discoveries, practical benefits or new technologies.

- Sponsor assistance to at least 2 leading undergraduate institutions to develop courses that enable pre-service science educators to become proficient in Earth system science.

- Continue to train a pool of highly qualified scientists and educators in Earth science and remote sensing by sponsoring approximately 140 fellowships (50 of which are new) and a total of 30 New Investigator Program awards.

- Work with at least one professional society to develop content standards for professional practice of Earth remote sensing.

Strategic Goal (III): Develop and adopt advanced technologies to enable mission success and serve national priorities.

New and less costly remote sensing capabilities are made possible by targeted investment in advanced technologies. These technologies will make possible the next generation of weather, climate and Earth systems monitoring satellites. They will leverage advances in information technologies to make vast quantities of Earth science data useful and accessible to scientists, practitioners, and the public.

Objective (IIIA): Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation.

Annual Performance Goal 2Y25: Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, advancing them to a maturity level where they can be infused into new missions with shorter development cycles.

New technology enables measurements that have never been previously made. Often, these measurements enable the early warnings to the public of natural hazards (ozone, chemical or particulate threats) or life threatening weather conditions and allow study of Earth from new vantagepoint of space. Alternatively, many new technologies reduce the cost of existing measurements while improving their quality. Predictive information can be generated for the public with more reliability, at lower cost and in delivery of resulting information in a shorter period.

- Annually advance 25% of funded technology developments one Technology Readiness Level (TRL)
- Mature 2-3 technologies to the point where they can be demonstrated in space or in an operational environment.
- Enable one new science measurement capability or significantly improve performance of an existing one.

Objective (IIIB): Develop advanced information technologies for processing, archiving, accessing, visualizing, and communicating Earth science data.

High-end computational modeling capabilities will enable in-depth analysis and simulation of earth system processes. This analysis will lead to higher quality, more refined characterization of the Earth system and longer-range predictions of natural hazards or life threatening weather conditions.

Annual Performance Goal 2Y26: Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological processes affecting the earth.

- Successfully establish networked high performance computer testbed for Earth science modeling challenges.

- Finalize Earth science multidisciplinary, integrated Modeling Framework requirements by holding successful system design review.

Annual Performance Goal 2Y27: Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations.

- Attain a three time improvement over negotiated baseline for three to eight Earth Science modeling codes transferred to the high performance computer testbed.

- Successfully demonstrate up to three Earth science modeling codes interoperating on a functioning Modeling Framework prototype.

Objective (IIIC): Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction.

Lowering overall costs to the government, collaboration permits NASA to utilize other agencies' skills and resources, precluding inefficient duplication of missions and research efforts.

Annual Performance Goal 2Y28: Collaborate with other Federal and international agencies in developing and implementing better methods for using remotely sensed observations.

- Continue to take advantage of collaborative relations with U.S. Geological Survey (USGS), U.S. Department of Agriculture (USDA) and Environmental Protection Agency (EPA) to promote the use of remotely sensed data and information to accomplish U.S. strategic scientific, environmental and economic objectives.

- Demonstrate enhanced interoperability and interconnectivity of international remote sensing information systems and services through NASA's participation in the Committee on Earth Observation Satellites (CEOS) Working Group on Information Systems and Services.

- Demonstrate enhanced mission coordination and complementarity of remote sensing data through NASA's participation in the CEOS Working Group on Calibration and Validation.

- Demonstrate the establishment of an agreed international approach to an integrated global observing strategy for the oceans and the terrestrial carbon cycle through participation in the Integrated Global Observing Strategy - Partners (IGOS-P).

Enterprise-Wide Activities that enable achievement of Earth Science strategic goals.

Annual Performance Goal 2Y29: Successfully develop, have ready for launch, and operate instruments on at least two spacecraft to enable Earth Science research and applications goals and objectives.

- Successfully develop and have ready for launch at least two spacecraft.
- At least 90% of the total on-orbit instrument complement will be operational during their design lifetime.

Annual Performance Goal 2Y30: Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting 4 of 5 performance indicators.

- Make available data on seasonal or climate prediction, and land surface changes to users within 5 days of their acquisition.
- Increase by 50% the volume of data acquired and archived by NASA for its research programs compared to FY01.
- Increase the number of distinct NASA Earth Observing System Data and Information System (EOSDIS) customers by 20% compared to FY01.
- Increase scientific and applications data products delivered from the Earth Observing System (EOS) Distributed Active Archive Centers (DAACs) by 10% compared to FY01.
- User satisfaction: increase the number of favorable comments from DAAC and Earth Science Information Partner (ESIP) users as recorded in the customer contact logs over FY01; decrease total percentage of order errors by 5% over FY01.

Annual Performance Goal 2Y31: Safely operate airborne platforms to gather remote and *in situ* earth science data for process and calibration/validation studies.

- Support and execute seasonally dependent coordinated research field campaigns within one-week of target departure with the aid of airborne and sub-orbital platforms, as scheduled at the beginning of the fiscal year.

Verification and Validation

While performance indicators are noted in order to demonstrate significant scientific progress toward the annual performance goal, the ESE will also rely on external expert review. The Earth Science Advisory Committee of the NASA Advisory Council will conduct an annual assessment of the ESE's near-term science objectives. It will provide a qualitative progress measurement (Green, Yellow, or Red). "Green" will indicate that the objective was met; "Yellow" will indicate a concern that an objective was not fully accomplished; and "Red" will indicate that events occurred that prevented or severely impaired the accomplishment of the objective. The assessment will include commentary to clarify and supplement the qualitative measures.

Earth System Science and Applications Advisory Committee (ESSAAC) is a committee of the NASA Advisory Council under the Federal Advisory Committee Act, and comprises outside scientific and technical experts from academia, industry and other government agencies. ESSAAC meets at least twice a year to review plans and progress in the ESE. After the end of each fiscal year, the ESE will provide to ESSAAC a self-assessment in each of the relevant objectives, highlighting performance against the metrics in the Performance Plan for that year. ESSAAC will deliberate internally and render its own assessment, which may confirm or modify ESE's self-assessment. ESSAAC's assessment will be reported in the Performance Report for that year. This process will be repeated annually.

The ESE will regularly review performance objectives as part of an existing monthly review process. Tracking current performance on a monthly basis for each specific FY02 annual performance goal enables the ESE to institute measures to ensure improvement and progress toward meeting its strategic goals.

Multi-year Performance Trend
Earth Science Enterprise

***New objectives have been developed for FY 2002. The targets can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

FY 99-01 Strategic Objective: Understand the causes and consequences of land-cover/land-use change

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Collect near-daily measurements of ocean color (index of ocean productivity from which calculations of ocean update of carbon are made). (Y3). Refresh the global archive of 30m land imagery from Landsat 7, two to three times per year. A single global archive has not been constructed since late 1970's. This will include a 15m panchromatic band (Y1).	SIMBIOS will merge MODIS ocean color data into the global ocean color time series, which began with Ocean Color Temperature Sensor (OCTS) and SeaWiFS. Use time series to understand and predict response of the marine ecosystem to climate change. Make data set available via the Goddard DAAC (0Y4). Continue the ocean color time series with 60% global coverage every 4 days (0Y3). Continue the development of a global land-cover/use change data set based on Landsat and EOS instrument, at seasonal refresh rate (0Y1).	Increase understanding of the dynamics of the global carbon cycle by developing, analyzing and documenting multi-year data sets and meeting at least 3 of 4 performance indicators in this research area (1Y3). Explain the dynamics of global carbon cycle by building improved models and prediction capabilities and meeting 2 of 2 performance indicators in this research area (1Y4).	Increase understanding of global ecosystems change by meeting at least 3 of 4 performance indicators (2Y3). Increase understanding about the changes in global land cover and land use and their causes by meeting at least 2 of 3 performance indicators (2Y8). Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle by meeting at least 4 of 5 performance indicators (2Y11).
Assessment	Y3 and Y1 were yellow	0Y4 was yellow. 0Y3 and 0Y1 were green.	TBD	TBD

FY 99-01 Strategic Objective: Understand the causes and consequences of land-cover/land-use change (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Collect near-daily global measurements of the terrestrial biosphere (index of terrestrial photosynthetic processes from which calculations of carbon uptake are made) from instruments on TERRA (Y2).	Continue to collect near-daily global measurements of the terrestrial biosphere (index of terrestrial photosynthetic processes from which calculations of carbon uptake are made) from instruments on TERRA (0Y2). Produce near-real-time fire monitoring and impact assessment based on Landsat and EOS inventory and process monitoring to provide an observational foundation for monitoring change in ecosystem productivity and disturbance. Post near-real-time assessments on a web site for quick access by researchers and regional authorities (0Y7).		Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity by meeting at least 2 of 3 performance indicators (2Y17). Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions by meeting 2 of 2 performance indicators (2Y18).
Assessment	Yellow	0Y2 was green. 0Y7 was green		TBD

***New objectives have been developed for FY 2002. The targets can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

FY 99-01 Strategic Objective: Predict seasonal-to-interannual climate variations

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	TRMM will begin the second of a 3-year sequence of instantaneous measurements of rainfall rates and monthly accumulations in the global tropics. This will be the first measurement of global tropical rainfall. Current uncertainty is 50 percent. TRMM data will reduce uncertainty to 10 percent. (Y4). QuikScat to provide 25km resolution wind speed & direction measurements over at least 90% of the ice-free oceans every two days. Resolution increases by a factor of two, and a 15% increase of coverage over previous measurement (Y5).	Establish a benchmark for global and regional rainfall measurements by combining TRMM measurements with measurements from other sources. Create maps of the diurnal cycle of precipitation for the first time. Combine the existing ten-year data set with TRMM measurements to validate climate models and demonstrate the impact of rainfall on short-term weather forecasting. Distribute through the Goddard DAAC for ease of access to science and operational users (0Y9).	Increase understanding of the dynamics of global water cycle by developing, analyzing, and documenting multi-year data sets and meeting 2 of 2 performance indicators in this research area. (1Y5). Explain the dynamics of global water cycle by building improved models and prediction capabilities and meeting at least 2 of 3 performance indicators in this research area (1Y6).	Increase understanding of global precipitation, evaporation and how the cycling of water is changing by meeting at least 3 of 4 performance indicators (2Y1). Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales by meeting 2 of 2 performance indicators (2Y2). Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least 4 of 6 performance indicators (2Y12)
Assessment		Green	TBD	TBD

FY 99-01 Strategic Objective: Predict seasonal-to-interannual climate variations (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Develop/improve methods to couple state-of-the-art land surface and sea ice models to a global coupled ocean-atmosphere model and use to predict regional climactic consequences of El Nino or La Nina occurrence in the tropical Pacific. Results of research will be published in the open literature and provided to NOAA's National Climate Prediction Center and the U.S. Navy's Fleet Numeric Prediction Center. Ultimate goal: develop a capability to significantly improve the prediction for seasonal-to-interannual climate variations and their regional climate consequences. The main focus is on North America (0Y10).		Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation by meeting 2 of 2 performance indicators (2Y16) Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling by meeting at least 2 of 3 performance indicators (2Y19). Increase understanding of the extent that transient climate variations can be understood and predicted by meeting at least 4 of 5 performance indicators (2Y20).
Assessment		Green		TBD

FY 99-01 Strategic Objective: Predict seasonal-to-interannual climate variations (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Measure production and radiative properties of aerosols produced by biomass burning in Africa based on SAFARI 2000 (field experiment) and EOS instruments. Includes extensive international participation. This burning is estimated to contribute one-half of global atmospheric aerosols (0Y11). Launch the NASA-CNES Jason-1 mission. This follow-on to TOPEX/ Poseidon is to achieve a factor-of-four improvement in accuracy in measuring ocean basin-scale sea-level variability. This is 1 order of magnitude better than that specified for TOPEX/Poseidon. (0Y12). Generate the first basin-scale high-resolution estimate of the state of the Pacific Ocean as part of the international Global Ocean Data Assimilation Experiment (GODAE) (0Y47).		
Assessment		0Y11 was green. 0Y12 was yellow 0Y47 was green.		

***New objectives have been developed for FY 2002. The targets can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

FY 99-01 Strategic Objective: Identify natural hazards, processes, and mitigation strategies

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	The Enterprise will provide the technology and instruments to create the first digital topographic map of 8o percent of Earth's land surface, everything between 60°N and 56°S. SRTM will be ready to launch in September 1999. (Y6). Use GPS array in southern California to monitor crustal deformation on a daily basis with centimeter precision; initiate installation of the next 100 stations. Data will be archived at JPL and run in models, with results given to the California Seismic Safety Commission and FEMA. (Y7).	Use Southern California Global Positioning System (GPS) array data to understand the connection between seismic risk and crustal strain leading to Earthquakes (0Y37). Develop models to use time-varying gravity observations for the first time in space (0Y38). Demonstrate the utility of spaceborne data for floodplain mapping with the Federal Emergency Management Agency (0Y39). Develop an automatic volcano cloud/ash detection algorithm employing EOS data sets for use by the Federal Aviation Administration (0Y40).	Increase understanding of the dynamics of the Earth's interior and crust by developing, analyzing, and documenting multi-year data sets and meeting 2 of 2 performance indicators in this research area (1Y11). Explain the dynamics of the Earth's interior and crust by building improved models and prediction capabilities and meeting 2 of 2 performance indicators in this research area (1Y12).	Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes by meeting at least 3 of 4 performance indicators (2Y6). Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes by meeting at least 4 of 5 performance indicators (2Y9).
Assessment	Green	Green	TBD	TBD

FY 99-01 Strategic Objective: Identify natural hazards, processes, and mitigation strategies (continued)

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	Use GPS data to test improved algorithms for sounding the atmosphere with the occulted GPS signal. Data will be archived at JPL and results published in science literature. (Y8).			
Assessment	Green			

***New objectives have been developed for FY 2002. The targets can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

FY 99-01 Strategic Objective: Detect long-term climate change, causes, and impacts

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	MODIS, MISR, ASTER, CERES (TERRA instruments) will begin to conduct daily observations of cloud properties such as extent, height, optical thickness and particle size. Data will be distributed through the Goddard DAAC (Y9). TERRA will map aerosol formation, distribution and sinks over the land and oceans (Y10). The TERRA instrument will achieve a 40-percent reduction in the uncertainty in Earth's radiation balance (that is improved angular models leading to an estimated error reduction in regional-scale monthly average net radiation of about 50 percent. (Y11).	Complete the collection of satellite data needed for the 17-year cloud climatology being developed under the International Satellite Cloud Climatology Project. Data will be used to improve the understanding and modeling of role of clouds in climate. Data will be available in the Goddard DAAC (0Y13). Continue the development of the global aerosol climatology data set and analysis of this climatology in climate models. Data will be available in the Goddard DAAC (0Y14). Provide for the continuation of the long-term, precise measurement of the total solar irradiance with the launch of EOS ACRIM (0Y15).	Increase understanding of the dynamics of long term climate variability by developing, analyzing, and documenting multi-year data sets and meeting at least 2 of 3 performance indicators in this research area (1Y7). Explain the dynamics of long term climate variability by building improved models and prediction capabilities and meeting at least 3 of 4 performance indicators in this research (1Y8).	Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least 3 of 4 performance indicators (2Y5). Increase understanding of the effects of clouds and surface hydrologic processes on climate change by meeting at least 4 of 5 performance indicators (2Y10). Increase understanding of global sea level and how it is affected by climate change by meeting at least 2 of 3 performance indicators (2Y14). Increase understanding of the extent that long-term climate trends can be assessed or predicted by meeting at least 4 of 5 performance indicators (2Y21).
Assessment	Yellow	All were green	TBD	TBD

FY 99-01 Strategic Objective: Detect long-term climate change, causes, and impacts (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Acquire, through a Radarsat repeat of Antarctic Mapping Mission conducted in Sept.-Oct. 1997, a second set of high-resolution radar data over all of Antarctica for comparison with baseline data set acquired in 1997, to identify changes on the ice sheet (0Y16). Publish the first detailed estimates of thickening/thinning rates for all major ice drainage basins of Greenland ice sheet derived from repeated airborne laser-altimetry surveys. Measures represent the baseline data set to compare with early GLAS data (July 2001 launch) (OY17). Initiate a program of airborne mapping of layers within the Greenland ice sheet to decipher the impact of past climate variation of polar regions (0Y18).		
Assessment		All were green		

FY 99-01 Strategic Objective: Detect long-term climate change, causes, and impacts (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Develop a remote-sensing instrument/technique for ocean surface salinity measurements from aircraft. Goal: to improve measurement accuracy to ` order of magnitude better than available in FY98. The ultimate goal is the capability to globally measure sea surface salinity from space (0Y19). Continue to improve the design and sophistication of a global climate system model, including use of higher resolution, to make it a state-of-the-art climate system model for projecting the climatic consequences at the regional level. Improvement will be manifested in increased resolution from added computing power and better numerical representations (0Y20).		
Assessment		0Y19 and 0Y20 were green		

***New objectives have been developed for FY 2002. The targets can be mapped to the following new objectives:**

Objective (1A): Discern and describe how the Earth is changing.
Objective (1B): Identify and measure the primary causes of change in the Earth system.
Objective (1C): Determine how the Earth system responds to natural and human-induced changes
Objective (1D): Identify the consequences of change in the Earth system for human civilization.
Objective (IE): Enable the prediction of future changes in the Earth system.

FY 99-01 Strategic Objective: Understand the causes of variation in atmospheric ozone concentration and distribution

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	TOMS data will be used for new retrieval methods to collect and analyze three new data products, including surface ultraviolet, tropospheric aerosols, and tropospheric columns. With SBUV/2 data, TOMS will make a continuous 20-year data set for total ozone-measuring effectiveness of Montreal Protocol. New and extended data products will be made available on TOMS web site. (Y12). Complete initiation of the full Southern Hemisphere Additional Ozonesonde network to obtain the first-ever climatology of upper tropospheric ozone in the tropics (Y14).	Implement the SAGE III Ozone Loss and Validation Experiments. Measurements will be made from October 1999 to March 2000 in the Arctic/high-latitude region from the NASA DC-8, ER-2, and balloon platforms. Will acquire correlative data to validate SAGE III data and assess high-latitude ozone loss (0Y22). (Green) Complete the analysis and publication of the PEM-Tropics-B field experiment (0Y23). (Green) Complete the Troposphere Chemistry aircraft instrument size and weight reductions (by ~40%) initiative (0Y24). (Green)	Increase understanding of the dynamics of atmospheric composition by developing, analyzing, and documenting multi-year data sets and meeting at least 4 of 5 performance indicators in this research area (1Y9). Explain the dynamics of atmospheric chemistry by building improved models and prediction capabilities and meeting at least 2 of 3 performance indicators in this research area (1Y10).	Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting 2 of 2 performance indicators (2Y4). Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least 3 of 4 performance indicators (2Y7). Increase understanding of stratospheric trace constituents and how respond to change in climate and atmospheric composition by meeting 2 of 2 performance indicators (2Y13).
Assessment	Yellow due to Russian implementation delay	All were green.	TBD	TBD

FY 99-01 Strategic Objective: Understand the causes of variation in atmospheric ozone concentration and distribution (cntinued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	With data from other atmospheric ozone programs, continue the detailed multi-aircraft study of troposphere chemistry over the tropical Pacific Ocean, especially the contribution of long-range transport of air from South America and Africa to unpolluted areas. Complete the field measurements phase of PEM-Tropics-B (rainy season) with an improved payload that has resulted from an initiative to develop a smaller, lighter payload with equal or better performance than PEM-Tropics-A (dry season). Results will be fully analyzed and published. (Y15).	Complete the planning for major new 2001 airborne/unmanned aerospace vehicle mission that will use a smaller Troposphere Chemistry aircraft instrument (0Y25).		Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least 4 of 5 performance indicators (2Y15). Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least 2 of 3 performance indicators (2Y22).
Assessment	Yellow due to Russian implementation delay	Green		TBD

FY 99-01 Strategic Objective: Understand the causes of variation in atmospheric ozone concentration and distribution (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Use SAGE III to improve the collection and analysis of measurements provided by SAGE II, and add: nitrogen trioxide and chlorine dioxide measures; additional wavelength sampling to directly measure and retrieve aerosols throughout the troposphere; and, higher spectral resolution (Y13). With data from other atmospheric ozone programs, measure surface levels of chlorine- and bromine-containing chemical compounds addressed in the Montreal Protocol to document decreasing concentrations of regulated compounds and increasing concentrations of replacement compounds. Analyses will be provided to researchers supporting the WMO assessment process. (Y16).			
Assessment	Yellow due to Russian implementation delay			

FY 2002 Enterprise-Wide Supporting Activities/FY 99-01 Objective: Successfully launch spacecraft

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
APG #	The Enterprise will successfully launch three spacecraft within 10% of budget on average (Y35).	Launch three spacecraft and deliver two instruments for international launches within 10% of budget on average (0Y36).	Successfully develop, have ready for launch, and operate instruments on a least two spacecraft within 10 percent of their schedules and budget to enable Earth Science research and applications goals and objectives (1Y1).	Successfully develop, have ready for launch, and operate instruments on at least two spacecraft to enable Earth Science research and applications goals and objectives (2Y29).
Assessment	Yellow	Green	TBD	TBD

FY 2002 Enterprise-Wide Supporting Activities/FY 99-01 Objective: Implement open, distributed, and responsive data system architectures

	FY 1999	FY 2000	FY 2001	FY 2002
APG #	Make available data on prediction, land surface, and climate to users within 5 days (Y17). Increase the volume of data archived by 10% compared to FY97 (target = 139 terabytes). Goddard has been collecting trend data since FY94. (Y18). Increase the number of distinct customers by 20% compared to FY97 (target = 839,000). Goddard has been collecting trend data since FY94 (Y19). Increase products delivered from the DAACs by 10% compared to FY97 (target = 3.8 million). Goddard has been collecting trend data since FY94 (Y20).	EOSDIS make available data on prediction, land surface, and climate to users within five days (0Y26). EOSDIS will double the volume of data archived compared to FY98 (0Y27). EOSDIS will increase the number of distinct customers by 20% compared to FY98 (0Y28). EOSDIS will increase products delivered from the DAACs by 10% compared to FY98 (0Y29).	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives by meeting all performance indicators in this research area (1Y2).	Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting 4 of 5 performance indicators (2Y30). Safely operate airborne platforms to gather remote and in situ earth science data for process and calibration/validation studies (2Y31).
Assessment	Blue	All were blue.	TBD	TBD

Objective: Stimulate public interest in and understanding of Earth system science and courage young scholars to consider careers in science and technology/FY 99-01 Objective: Increase public understanding of Earth system science through education and outreach.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Award 50 new graduate student research grants and 20 early career postdoctoral fellowships in Earth Science. (Y21). Conduct over 300 teacher workshops to train teachers in use of Earth Science Enterprise education products (Y22). Increase number of schools participating in GLOBE from to 8,000, from 5,900 in FY98, a 35-percent increase; increase participating countries from 70 in FY98 to 72 (Y23).	Award 50 new graduate student research grants and 20 early career fellowships in Earth Science (0Y30). Conduct at least 300 workshops to train teachers in use of ESE education products (0Y31). Increase number of schools participating in GLOBE to 10,500, a 30% increase over FY99; increase participating countries to 77 (from 72). (0Y32).	Increase public understanding of Earth system science through formal and informal education by meeting at least 3 of 4 performance targets in this area (1Y18).	Share NASA's discoveries in Earth science with the public to enhance understanding of science and technology (2Y24).
Assessment	Green	0Y30 was green. 0Y31 was blue. 0Y32 was yellow.	TBD	TBD

Objective: Develop advanced technologies to reduce the cost and expand the capability for scientific Earth observation/FY 99-01 Objective: Develop and transfer advanced remote-sensing technologies.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Annually advance at least 25% of funded instrument technology developments one TRL (Y30). Demonstrate a new capability to double the calibration quality for moderate-resolution land imagery. (Y28). Annually transfer at least one technology development to a commercial entity for operational use (Y29).	Advance at least 25% of funded instrument technology development one TRL to enable future science missions and reduce their total cost (0Y35). Achieve a 50% reduction in mass for future land imaging instruments (0Y33). Transfer at least one technology development to a commercial entity for operational use (0Y34).	Achieve success with timely development and infusion of technologies. Enable future science missions by increasing technology readiness for mission concepts to reduce their total cost. Do this by meeting at least 3 of 4 performance indicators for this advanced technology area (1Y13).	Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, advancing them to a maturity level where they can be infused into new missions with shorter development cycles (2Y25).
Assessment	Green	0Y35 was blue 0Y33 and 0Y34 were green	TBD	TBD

Objective: Develop advanced information systems for processing, archiving, accessing, visualizing, and communicating Earth science data.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological processes affecting the earth (2Y26). Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations. (2Y27)
Assessment				TBD

Objective: Demonstrate scientific and technical capabilities to enable the development of practical tools for public and private-sector decision makers/FY 99-01 Strategic Objective: Extend the use of Earth Science research for regional, state, and local applications

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	Establish at least five Regional Earth Science Applications Centers (RESACs) (Y31). Complete solicitation for seven co-operative agreements with State and local governments in areas of land use planning, land capability analysis, critical areas management, and water resource management (Y33). Establish at least eight new projects, with USDA, in the areas of vegetation mapping and monitoring, risk and damage assessment, resources management and precision agriculture (Y32).	At least one of seven Regional Earth Science Applications Center (RESAC) becomes self-sustaining. Continue funding for the remaining centers (0Y41). Develop two new validated commercial information products as a result of verification and validation partnerships with industry (0Y46). Implement at least five joint applications research projects/partnerships with State and local governments in remote – sensing applications (0Y43).	Provide regional decision-makers with scientific and applications products/tools by meeting at least 7 of 8 performance indicators for this applications research area (1Y14). Improve access to and understanding of remotely sensed data and processing technology by meeting 3 of 3 performance indicators in this area (1Y15).	Provide regional decision-makers with scientific and applications products and tools (2Y23).
Assessment	Blue	0Y41 was yellow 0Y46 and 0Y43 were green	TBD	TBD

Objective: Partner with other agencies to develop and implement better methods for using remotely sensed observations in Earth system monitoring and prediction/FY 99-01 Strategic Objective: Extend the use of Earth Science research for regional, state, and local applications.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				Collaborate with other Federal and international agencies in developing and implementing better methods for using remotely sensed observations (2Y28)
Assessment				TBD

FY 99-01 Objective: Support the development of a robust commercial remote sensing industry

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Establish at least 75 commercial partnerships in "value-added" remote sensing product development; an increase from 37 over FY97 (Y34).	Focus EOCAP joint commercial applications research to develop 20 new market commercial products (e.g., oil spill containment software by EarthSat and map sheets products by ERDAS, Inc.). (0Y44). Provide three commercial sources of science data (from the data buy) for global change research and applications (0Y45). Develop two new validated commercial information products as a result of verification and validation partnerships with industry (0Y46).	Stimulate the development of a robust commercial remote sensing industry by meeting at least 4 of 5 performance indicators in this area (1Y16). Increase efficiencies in food and fiber production with the aid of remote sensing by meeting the performance indicator in this area (1Y17).	
Assessment	Blue	0Y44 was yellow 0Y45 and 0Y46 were green	TBD	

FY 99-01 Strategic Objective: Make major scientific contributions to national and international environmental assessments

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	Make significant contribution to World Meteorological Organization (WMO) Ozone Assessment by providing a lead chapter author and most of the global-scale data (Y26). Contribute model results of climate affects of measured aircraft emissions and provide report to IPCC assessment report (Y24). Make significant contributions to US. Regional/national assessments in partnership with U.S. Global Change Research Program agencies (Y25). Provide lead chapter author and most of the global-scale data and contributing researchers to the IPCC Assessment Report, sponsored by the United Nations Environment Programme and WMO (Y27).	Sponsor two regional national assessment studies of environmental variations and natural resources vulnerability (0Y48). (Green) Complete the contribution to the First National Assessment of the Potential Consequences of Climate Variability and Change: provide climate scenario information, support the national synthesis, conduct several regional U.S. analyses, and provide supporting research for sector analyses. Provide information to the U.S. National Assessment Coordination Office. (0Y5). (Green)	Note: incorporated into science objectives in FY01 and beyond	
Assessment	Green	Green		

FY 99-01 Strategic Objective: Make major scientific contributions to national and international environmental assessments (continued)

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		Conduct the first regional international assessment in South Africa: quantify the effects of climate variability and management practices on the environment, publish in open literature, and provide analyses to IPCC for their 2000 assessment. (0Y6). Provide the first global, regional and country-by country forest cover inventory in support of national and international needs research, operational and policy communities. Publish and provide to IPCC and the International Geosphere-Biosphere Programme for their 2000 assessment report (0Y8).		
Assessment		0Y6 was yellow. 0Y8 was green.		

Earth Science Enterprise FY 2002	Budget Category	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
2Y1: Increase understanding of global precipitation, evaporation and how the cycling of water is changing by meeting at least 3 of 4 performance indicators.		X		X	X	
2Y2: Increase understanding of global ocean circulation and how it varies on interannual, decadal, and longer time scales by meeting 2 of 2 performance indicators.				X	X	
2Y3: Increase understanding of global ecosystems change by meeting at least 3 of 4 performance indicators		X			X	
2Y4: Increase understanding of stratospheric ozone changes, as the abundance of ozone-destroying chemicals decreases and new substitutes increases by meeting 2 of 2 performance indicators.		X		X	X	
2Y5: Increase understanding of change occurring in the mass of the Earth's ice cover by meeting at least 3 of 4 performance indicators.		X	X		X	
2Y6: Increase understanding of the motions of the Earth, the Earth's interior, and what information can be inferred about the Earth's internal processes by meeting at least 4 of 5 performance indicators.			X		X	
2Y7: Increase understanding of trends in atmospheric constituents and solar radiation and the role they play in driving global climate by meeting at least 3 of 4 performance indicators.		X			X	
2Y8: Increase understanding about the changes in global land cover and land use and their causes by meeting at least 2 of 3 performance indicators.		X			X	
2Y9: Increase understanding of the Earth's surface and how it is transformed and how such information can be used to predict future changes by meeting at least 4 of 5 performance indicators.		X	X		X	

Earth Science Enterprise FY 2002	Budget Category	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
2Y10: Increase understanding of the effects of clouds and surface hydrologic processes on climate change by meeting at least 4 of 5 performance indicators.		X			X	
2Y11: Increase understanding of how ecosystems respond to and affect global environmental change and affect the global carbon cycle by meeting at least 4 of 5 performance indicators.		X		X	X	
2Y12: Increase understanding of how climate variations induce changes in the global ocean circulation by meeting at least 4 of 6 performance indicators.		X			X	
2Y13: Increase understanding of stratospheric trace constituents and how they respond to change in climate and atmospheric composition by meeting 2 of 2 performance indicators.				X	X	
2Y14: Increase understanding of global sea level and how it is affected by climate change by meeting at least 2 of 3 performance indicators.					X	
2Y15: Increase understanding of the effects of regional pollution on the global atmosphere, and the effects of global chemical and climate changes on regional air quality by meeting at least 4 of 5 performance indicators.		X		X	X	
2Y16: Increase understanding of variations in local weather, precipitation and water resources and how they relate to global climate variation by meeting 2 of 2 performance indicators.		X		X	X	
2Y17: Increase understanding of the consequence of land cover and land use change for the sustainability of ecosystems and economic productivity by meeting at least 2 of 3 performance indicators.		X			X	

Earth Science Enterprise FY 2002	Budget Category	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
2Y18: Increase understanding of the consequences of climate and sea level changes and increased human activities on coastal regions by meeting 2 of 2 performance indicators.		X			X	
2Y19: Increase understanding of the extent that weather forecast duration and reliability can be improved by new space-based observations, data assimilation and modeling by meeting at least 2 of 3 performance indicators.				X	X	
2Y20: Increase understanding of the extent that transient climate variations can be understood and predicted by meeting at least 4 of 5 performance indicators.		X		X	X	
2Y21: Increase understanding of the extent that long-term climate trends can be assessed or predicted by meeting at least 4 of 5 performance indicators.					X	
2Y22: Increase understanding of the extent that future atmospheric chemical impacts on ozone and climate can be predicted by meeting at least 2 of 3 performance indicators.					X	
2Y23: Provide regional decision-makers with scientific and applications products and tools.					X	
2Y24: Share NASA's discoveries in Earth science with the public to enhance understanding of science and technology.					X	
2Y25: Successfully develop and infuse technologies that will enable future science measurements, and/or improve performance and reduce the cost of existing measurements. Increase the readiness of technologies under development, advancing them to a maturity level where they can be infused into new missions with shorter development cycles.					X	

Earth Science Enterprise FY 2002	Budget Category	Earth Observing System	Earth Explorers	Operations	Research and Technology	Investments
2Y26: Develop hardware/software tools to demonstrate high-end computational modeling to further our understanding and ability to predict the dynamic interaction of physical, chemical and biological processes affecting the earth.					X	
2Y27: Develop baseline suite of multidisciplinary models and computational tools leading to scalable global climate simulations by meeting at least 2 of 3 performance indicators.					X	
2Y28: Collaborate with other Federal and international agencies in developing and implementing better methods for using remotely sensed observations.					X	
2Y29: Successfully develop, have ready for launch, and operate instruments on at least two spacecraft to enable Earth Science research and applications goals and objectives.		X	X		X	
2Y30: Successfully disseminate Earth Science data to enable our science research and applications goals and objectives. Success will equate to meeting 4 of 5 performance indicators.		X			X	
2Y31: Safely operate airborne platforms to gather remote and in situ earth science data for process and calibration/validation studies.					X	

Human Exploration and Development of Space Enterprise (HEDS)

Mission

As we enter a new millennium, people the world over are reflecting on the accomplishments of the past and speculating about opportunities of the future. Some of the most inspiring and important accomplishments of the past four decades have resulted from the space program: events such as the planet-wide impact of the Apollo landings on the moon and images of the Earth; discoveries such as the astonishing Hubble Space Telescope (HST) photos of solar system formation; achievements such as the sending of the first human spacecraft—Pioneer and Voyager spacecraft—beyond our solar system; and new capabilities such as communications and weather satellites. Space has touched the lives of many hundreds of millions worldwide.

The mission of HEDS is to expand the frontiers of space and knowledge by exploring, using, and enabling the development of space for human enterprise. To achieve this mission, NASA's Human Exploration and Development of Space (HEDS) Enterprise is pursuing four strategic goals:

- Explore the space frontier
- Enable humans to live and work permanently in space
- Enable the commercial development of space, and
- Share the experience and benefits of discovery

We begin with the foundation of the Space Shuttle and the International Space Station, now under construction in Earth orbit, and look to the future by initiating technology development and commercialization in space.

We also aspire to make possible U.S. leadership of international efforts to extend permanently human presence beyond the bounds of Earth, involving both machines and humans as partners in innovative approaches to exploration. We will engage the private sector in the commercial development of space in order to enable the continuation of current space business and the creation of new wealth and new jobs for the U.S. economy.

Accomplishment of these goals will enable historic improvements in our understanding of nature, in human accomplishment, and in the quality of life. The Human Exploration and Development of Space Strategic Plan is a first step. This performance plan shows how we plan to measure our success.

Resource Requirements

(NOA, dollars in millions)

	FY1999	FY 2000	FY 2001	FY 2002
$M	$6,045.8	$5,977.9	$5,972.5	$7,248.2
CS FTE	7,209	7,416	7,779	8,092

Implementation Strategy

Goal 1 - Explore the Space Frontier
There are certain ideas that many believe to be inherent in the human psyche and integral to American culture: ambition for progress, curiosity about the unknown, the need to pose profound questions and to answer them, the concept of new frontiers that—once achieved—promise a better quality of life for all peoples. Space is such a frontier. Earth orbit, the Moon, near-Earth space, Mars and the asteroids, eventually the moons of the giant planets of the outer solar system, and someday more distant worlds—these are collectively the endless, ever-expanding frontier of the night sky under which the human species evolved and toward which the human spirit is inevitably drawn. It is a fundamental goal of NASA to expand the space frontier progressively through human exploration, utilization of space for research, and commercial development.

Strategic Objectives

- Invest in the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration.
- Conduct engineering research on the International Space Station to enable exploration beyond Earth orbit.
- Enable human exploration through collaborative robotic missions.
- Define innovative human exploration mission approaches.
- Develop exploration/commercial capabilities through private sector and international partnerships.

Goal 2 - Enable Humans to Live and Work Permanently in Space
Advances in technology notwithstanding, the human element continues to be the major factor in the success or failure of most terrestrial enterprises. In many cases, innovative technologies are most effective when used to leverage or enhance the productivity of humans. Moreover, the human element is a quintessential component in the public's continuing interest in, and support for the space program. Human presence will be an essential factor in successfully opening the space frontier and expanding knowledge through research in space. As our activities in space grow, so too must human involvement. In this way, we open the door to an array of benefits, tangible and intangible, for the people of the United States and the world. It is, therefore, a goal of NASA to enable and establish permanent and productive human presence in space, to advance America's aspirations and opportunities in space through new technologies and new ways of doing business.

Strategic Objectives

- Provide and make use of safe, affordable, and improved access to space.
- Operate the International Space Station to advance science, exploration, engineering, and commerce.
- Ensure the health, safety, and performance of humans living and working in space.
- Meet sustained space operations needs while reducing costs.

Goal 3 - Enable the Commercial Development of Space

Commerce is essential to human society; free market transactions are the foundation of the dramatic progress humankind has made during the past several centuries. Wherever humans go and wherever they live, there too is commerce. Moreover, the free market is an effective mechanism for delivering tangible benefits from space broadly to the American people.

If humanity is to explore and develop space, to better exploit the space environment for profound scientific discoveries, and someday to settle the space frontier, it may be through the continuing expansion of the private sector—of individuals and of industry—into space. As we open the space frontier, we must therefore seek to expand the free market into space.

It is a goal of NASA to enable the commercial development of space.

Strategic Objectives

- Improve the accessibility of space to meet the needs of commercial research and development.
- Foster commercial endeavors with the International Space Station and other assets.
- Develop new capabilities for human space flight and commercial applications through partnerships with the private sector.

Goal 4 - Share the Experience and Benefits of Discovery

Americans—of all backgrounds—should have the opportunity to share in the experience and benefits of space exploration and development. During the past four decades, ambitious human space flight missions have inspired generations of young people to undertake careers in science, mathematics, and engineering— benefiting both themselves and society. The space program can enrich society by directly enhancing the quality of education. Terrestrial applications of technologies developed for space have saved many lives, made possible medical breakthroughs, created countless jobs, and yielded diverse other tangible benefits for Americans. The further commercial development of space will yield still more jobs, technologies, and capabilities to benefit people the world over in their everyday lives. A goal of NASA is therefore to share the experience, the excitement of discovery, and the benefits of human space flight with all.

Strategic Objectives

- Engage and involve the public in the excitement and the benefits of—and in setting the goals for—the exploration and development of space.
- Provide significantly more value to significantly more people through exploration and space development efforts.
- Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

Performance Measures

Goal 1: Explore the Space Frontier

Objective: Invest in the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration.

Public Benefit: Pursuing the technologies that will be needed for future ambitious missions of human/robotic exploration of space will make possible an expanded scope for human commerce and an improved quality of life by enabling potential high-value new space industries (e.g., advanced communications satellites, manufacturing in space, R&D in space, public space travel, space utilities, and others) while improving the quality of life (e.g., through advances in our understanding of human physiology and human factors, in medicine and medical systems) and advancing the general economy (through the application of these technologies in terrestrial commercial markets).

Annual Performance Goal 2H01: Begin the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration missions beyond LEO.

- Select and fund at least 10-15 cooperative R&D projects through the HTCI focused R&T program, addressing common and competing technologies for human/robotic missions beyond LEO.

Objective: Conduct engineering research on the International Space Station to enable exploration beyond Earth orbit.

Public Benefit: Many of the key technologies needed for future human/robotic exploration and development of space will require testing and later demonstrations in the actual space environment before they can bee cost-effectively applied in future space systems. Conducting engineering research and development at the ISS, will result in more timely, affordable and successful application of these new technologies (including the capability to design to cost and implement to cost for future HEDS projects). In addition, the space application of these technologies will result in expanded scope for human commerce and an improved quality of life by enabling potential high-value new space industries (e.g., advanced communications satellites, manufacturing in space, R&D in space, public space travel, space utilities, and others) while improving the quality of life (e.g., through advances in our understanding of human physiology and human factors, in medicine and medical systems).

Annual Performance Goal 2H02: Test at the International Space Station competing technologies for human missions beyond LEO, in cooperation with other agencies and international partners, and with US industry.

- Complete preliminary definition of no fewer than 5 potential technology flight experiments and demonstrations that could be implemented at the International Space Station.

Objective: Enable human exploration through collaborative robotic missions.

Public Benefit: A better understanding (at the earliest possible dates) of the space and planetary environments to which human explorers will one day travel will make possible a more focused, more effective and lower cost investment to develop the technologies needed for future human/robotic exploration and development of space. This knowledge and understand will also make possible reduced risks to the health and safety of future astronauts. Overall, pursuing collaborative robotic missions will result future human/robotic exploration missions with lower costs and greater benefits that would be otherwise achievable.

Annual Performance Goal 2H03: Provide reliable launch services for approved missions.

- NASA success rate at or above a running average of 95% for missions noted on the Flight Planning Board manifest and launched pursuant to commercial launch service contracts.

Objective: Define innovative human exploration mission approaches.

Public Benefit: New concepts at all levels – technologies, systems and architectures – are needed to make possible dramatic reductions in the anticipated costs and risks, and substantial increases in the returns and benefits expected from future human/robotic exploration missions beyond low Earth orbit. In addition, these innovative approaches are anticipated to provide a viable foundation for many opportunities to advanced the commercial development of space, making possible a range of future new space industries (e.g., R&D in space, advances in space communications, etc.) that will promote the continuing strength of the US aerospace industry in the world economy.

Annual Performance Goal 2H04: Identify and evaluate candidate approaches for 100- to 1000- day human missions capable of a 5- to 10- fold cost reduction--while increasing safety and effectiveness (compared to 1990s projections).

- Select and fund at least 5 proposals through the HTCI focused R&T program that feature: (1) highly innovative new advanced systems concepts and architecture studies for HEDS/OSF, and (2) a range of mission studies examining potential future options.

Objective: Develop exploration/commercial capabilities through private sector and international partnerships.

Public Benefit: The use of private sector partnerships to develop exploration/commercial capabilities will accelerate the timely commercial application of the new technologies and concepts emerging from human/robotic exploration efforts – moving forward the date when public benefits can be expected. In addition, by involving the US private sector in the development of the needed technologies early on will enhance the subsequent development and conduct of exploration missions, resulting in lower risks and costs in future projects. Similarly, engaging international partners in the pursuit of appropriate exploration/commercial capabilities will make possible well-chosen and more-effective international collaboration in the conduct of future missions, reducing the costs and risks for the US of future projects.

Annual Performance Goal 2H05: Develop and test --on the ground and in space-- competing technologies for human missions beyond LEO in cooperation with international partners.

- Organize and conduct an "international forum" at which preliminary concepts, plans and technology options for future human/robotic exploration and development of space are reviewed.

Goal 2: Enable Humans to Live and Work Permanently in Space

Objective: Provide and make use of safe, affordable, and improved access to space.

Public Benefit: Successfully meeting goal 2H06 allows researchers to apply the knowledge gained from flying payloads on the Space Shuttle thus assuring a positive return on the public's investment in space transportation

Annual Performance Goal 2H06: Assure public, flight crew, and workforce safety for all Space Shuttle operations, measured by the following:

- Achieve zero type A or B mishaps in FY 2002.
- Achieve an average of 8 or fewer flight anomalies per Space Shuttle mission

Public Benefit: Successfully meeting goal 2H07 allows researchers to apply the knowledge gained from flying payloads on the Space Shuttle thus assuring a positive return on the public's investment in space transportation

Annual Performance Goal 2H07: Safely meet the FY 2002 manifest and flight rate commitment. Annual performance goal is measured for Space Shuttle performance only.

- Achieve 100% on-orbit mission success for all flights in FY 2002. For this metric, mission success criteria are those provided to the prime contractor (SFOC) for purposes of determining successful accomplishment of the performance incentive fees in the contract.

Public Benefit: Ensuring the most effective and efficient access to space for primary payload customers while supporting the safety and reliability of the Shuttle transportation system.

Annual Performance Goal 2H08: Maintain a "12-month" manifest preparation time.

- Baselined Flight Requirements Document (FRD) tracks achievement of this goal and it defines the primary cargo manifest that uses the "12 month" template.

Public Benefit: Ensuring a safe and reliable space transportation system that maximizes long-term benefits to the public through support to the ISS program and other primary payload customers.

Annual Performance Goal 2H09: Have in place a Shuttle safety investment program that ensures the availability of a safe and reliable Shuttle system for ISS assembly and operations.

- Meet the major FY 2002 Space Shuttle Safety Upgrade milestones. For this metric, major milestones are defined to be the Preliminary Design Review dates, Critical Design Review dates, Ready dates for upgrade installation/integration with flight hardware/software, and Ready dates for first flight

Objective: Operate the International Space Station to advance science, exploration, engineering, and commerce.

Public Benefit: Meeting operations targets and beginning research activities will provide many benefits of space research directly to the public through new discoveries and improved technology applications in areas such as medicine, industrial processes and fundamental knowledge.

Annual Performance Goal 2H10: Demonstrate ISS on-orbit vehicle operational safety, reliability, and performance.

- Zero safety incidents (i.e. no on-orbit injuries)
- Actual resources available to the payloads measured against the planned payload allocation for power, crew time, and telemetry. (green = 80% or greater)

Public Benefit: Meeting development targets and beginning research activities will provide many benefits of space research directly to the public through new discoveries and improved technology applications in such areas as medicine, industrial processes and fundamental knowledge.

Annual Performance Goal 2H11: Demonstrate ISS program progress and readiness at a level sufficient to show adequate readiness in the assembly schedule.

- Conduct monthly status reviews to show maturity and preparation of flight readiness products. Maintaining 80% of define activities are within scheduled targets (green).

Public Benefit: Improving life on Earth. Successfully implementing goal 2H12 brings the many benefits of space research directly to the public through new discoveries and improved technology applications in areas such as medicine, industrial processes and fundamental knowledge.

Annual Performance Goal 2H12: Successfully complete 90% of the ISS planned mission objectives.

- Achieve 90% on-orbit mission success for planned ISS assembly and logistics activities on the Space Shuttle flights scheduled for FY 2002.
- Sum total of the successfully accomplished primary mission objectives divided by the total number of mission objectives per year.

Public Benefit: Improving life on Earth. Successfully implementing goal 2H13 brings the many benefits of space research directly to the public through new discoveries and improved technology applications in areas such as medicine, industrial processes and fundamental knowledge.

Annual Performance Goal 2H13: Demonstrate progress toward ISS research hardware development.

- Conduct end of the year review to show payload facility development to planned comparison. Maintaining actual schedule within 15% of original planned schedule for that year-- green.

Objective: Ensure the health, safety, and performance of humans living and working in space.

Public Benefit: Competition that promotes partnering of industries and academia with NASA to discover new approaches and technologies can help NASA achieve its goals while creating new business opportunities and supporting education.

Annual Performance Goal 2H14: Select and fund at least 3-5 proposals through the HTCI focused R&T program that feature:

  - o Highly innovative new technology development efforts in selected areas associated with human safety and performance in space (e.g., Extravehicular Activity (EVA) systems)

- Using a competitive solicitation process, select, fund, and complete the first round of:
  - o Highly innovative new technology development efforts in selected areas associated with human safety and performance in space (e.g., Extravehicular Activity (EVA) systems) through the HTCI focused R&T program.

Objective: Meet sustained space operations needs while reducing costs.

Public Benefit: The public's investment in space operations demands NASA's attention to safety first and cost reduction whenever possible. We are accountable for maximizing the return on the public's investment.

Annual Performance Goal 2H15: The Space Communications program will conduct tasks that enable commercialization and will minimize investment in government infrastructure for which commercial alternatives are being developed.

- Increase the percentage of the space operations budget allocated to the acquisition of communications and data services from the commercial sector from 15% in FY01 to 20% in FY 2002.

Public Benefit: The public's investment in space operations demands NASA's attention to safety first and cost reduction whenever possible. We are accountable for maximizing the return on the public's investment.

Annual Performance Goal 2H16: Performance metrics for each mission will be consistent with detailed program and project operations requirements in project Service Level Agreements

- Achieve at least 95 percent of planned data delivery for space flight missions.

Goal 3: Enable the Commercial Development of Space

Objective: Improve the accessibility of space to meet the needs of commercial research and development.

Public Benefit: Promote continuous research and development activities through the International Space Station assembly period.

Annual Performance Goal 2H17: Provide an average of five mid-deck lockers on each Space Shuttle mission to the International Space Station for research.

- Demonstrate that an average of five mid-deck lockers were used to support research on Space Shuttle Mission going to the ISS (source Space Station manifest).

Public Benefit: New commercially developed launch services will be able to compete for NASA launches when they meet NASA's risk mitigation policy.

Annual Performance Goal 2H18: Establish mechanisms to enable NASA access to the use of U.S. commercially developed launch systems.
- NASA launch service contracts in place or planned with annual on-ramps for newly developed commercial launch services as they meet NASA's risk mitigation policy.

Objective: Foster commercial endeavors with the International Space Station and other assets.

Public Benefit: NASA is undertaking reforms and developing a plan to ensure the future Space Station costs will remain within the President's FY2002 Budget plan.

Annual Performance Goal 2H19: Develop and execute a management plan and open future Station hardware and service procurements to innovation and cost-saving ideas through competition, including launch services and a Non-Government Organization for Space Station research.
- Implement management plan -- Management plan contains reforms that strengthen headquarters involvement, increases communications, provide more accurate assessment and maintains budget accountability.

Objective: Develop new capabilities for human space flight and commercial applications through partnerships with the private sector.

Public Benefit: Competition that promotes partnering of industries and academia with NASA to discover new approaches and technologies can help NASA achieve its goals while creating new business opportunities and supporting education.

Annual Performance Goal 2H20: Conduct a competitive solicitation and selection process that will fund through the HEDS research and technology (R&T) program HTCI (HEDS Technology and Commercialization Initiative):
  - Systems studies assessing the commercial potential associated with various prospective HEDS infrastructures/capabilities,
  - New technology development and demonstration efforts with potential longer-term commercial space value.
- Using a competitive solicitation process, select, fund, and complete the first round of:
  - Systems studies assessing the commercial potential associated with various prospective HEDS infrastructures/capabilities,
  - New technology development and demonstration efforts with potential longer-term commercial space value through the HTCI focused R&T program.
- Also;

- Develop, in conjunction with discussions with key international space organizations, and seek management approval for an approach for undertaking the formulation of international partnerships for the development and/or demonstration of HEDS capabilities.

Public Benefit: Progress in implementing 2H21 will transition NASA to the Research and Development (R&D) organization that was envision as its primary responsibility over 40 years ago. Partnership with commercial investors brings the results and benefits of living and working in space to the public more quickly than the government could do by itself.

Annual Performance Goal 2H21: Continue implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor.

- Pending completion of cost benefit analyses, add the Hamilton Sundstrand and Johnson Engineering contracts for Extravehicular Activity to the Space Flight Operations Contract (SFOC).
- Negotiate an extension of the Space Flight Operations Contract (SFOC) by the end of the Fiscal Year.
- Define criteria and get Space Flight Operations Contract (SFOC) contractor agreement for further contract consolidation and shuttle privatization, which assures maintenance of shuttle system safety.

Goal 4: Share the Experience and Benefits of Discovery

Objective: Engage and involve the public in the excitement and the benefits of ~~and~~ in setting the goals for ~~the~~ exploration and development of space.

Public Benefit: Continuing to improve public involvement in setting the goals HEDS activities will assure that future exploration and development of space programs are well aligned with the interests and the intentions of the primary constituents for NASA exploration programs, resulting overtime in programs and projects that are more cost-effective in achieving public goals and objectives.

Annual Performance Goal 2H22: Competitively select and fund at least 5 activities to identify potential opportunities for high public value HEDS activities, including potential media access and/or public involvement in future HEDS missions.

- Select and fund at least 5 proposals through the HTCI focused R&T program that feature studies to identify potential opportunities for high public value HEDS activities, including potential public involvement in future HEDS missions.

Objective: Provide significantly more value to significantly more people through exploration and space development efforts.

Public Benefit: Continuing to improve public involvement in the conduct of and results from future HEDS activities will assure that future exploration and development of space programs are well understood by the primary constituents for NASA exploration programs. In addition, more effective communication of the knowledge and technologies resulting from HEDS activities will assure the move rapid transition of these innovations into private sector applications, with resulting benefits to the economy and quality of life.

Annual Performance Goal 2H23: Establish a focused customer engagement process to significantly increase our value to significantly more people by enabling the public to guide the formulation of HEDS goals, objectives, programs and missions.

- Develop, through one or more public meetings a HEDS outreach plan, featuring an approach to communicate broadly the new knowledge, breakthrough technologies and innovative capabilities associated with various prospective HEDS Enterprise activities.

Annual Performance Goal 2H24: Expand public access to HEDS missions information (especially ISS) by working with industry to create media projects and public engagement initiatives that allow "first-hand" public participation using telepresence for current missions, and virtual reality or mock-ups for future missions beyond Earth orbit.

- Museums – track the number of science museums and other informal education forums incorporating first person participation with the ISS.
- Public Web presence – track number and duration of visits to the HEDS website

Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

Public Benefit: HEDS is an important investment in the future of the US. By advancing the academic achievements of the nation, HEDS can contribute to a better quality of life in the future by inspiring today's US students and faculty to excellence in the sciences, mathematics, and engineering. Similarly, by effectively advancing scientific and technological achievements, new discoveries and new industries will result, contributing to a stronger economy in the future.

Annual Performance Goal 2H25: Establish initial partnerships with educators at all levels (K-12 and universities) in order to increase the involvement of faculty and students in HEDS.

- Create no fewer than 10 "HEDS Student Challenge Projects" nation-wide, involving internet-based collaborative teams to bring educators, students and NASA technologists/scientists together to pursue innovative solutions to HEDS challenges.

Verification and Validation

Internal Assessment

Interim evaluation and monitoring of performance targets will be conducted – as required – as an element of regular meetings of the Office of Space Flight and HEDS Management Boards. As a matter of NASA policy, relevant HEDS performance targets are included in the HEDS portion of the NASA's performance plans submitted by the Associate Administrator of the Office of Space Flight.

Final data collection, reporting and verification for inclusion in the Annual Performance Report will rely on several different processes depending on the particular Annual Performance Goal. Wherever possible, a specific tangible product has been identified in the indicator for individual performance goals to strengthen the validation process.

For many HEDS performance goals, (e. g. Space Shuttle in-flight anomalies, Space Station assembly milestones) verification of performance is straightforward and progress is monitored through regular management channels and reports.

External Assessment

To assist in evaluating those performance goals that are more difficult to associate with specific tangible products, HEDS will employ an annual external assessment process. An OSF Advisory Committee reviews and evaluates OSF performance targets.

MULTI-YEAR PERFORMANCE TREND

Human Exploration and Development of Space Enterprise (HEDS)

Invest in the development of high-leverage technologies to enable safe, effective, and affordable human/robotic exploration.

	FY 1999	FY 2000	FY 2001	FY 2002
Explore the Space Frontier		0H38: In coordination with other Enterprises, develop and implement tests and demonstrations of capabilities for future human exploration in the areas of advanced space power, advanced space transportation, information and automation systems, and sensors and instruments.	1H32: Initiate the HEDS Technology/Commercialization program and establish a synergistic relationship with industry.	2H1: Begin the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration missions beyond LEO.
Assessment	N/A	Yellow	TBD	TBD

Conduct engineering research on the International Space Station to enable exploration beyond Earth orbit.

Explore the Space Frontier				2H2: Test at the International Space Station competing technologies for human missions beyond LEO, in cooperation with other agencies and international partners, and with US industry.
Assessment				TBD

Enable human exploration through collaborative robotic missions

	FY 1999	FY 2000	FY 2001	FY 2002
Explore the Space Frontier		OH35: Complete the integration and testing of the Mars In-situ Propellant Production Precursor (MIP) flight unit for the 2001 Mars Surveyor mission.	1H1: Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 missions.	
Assessment		Red	TBD	
Explore the Space Frontier				2H3: Provide reliable launch services for approved missions. • NASA success rate at or above a running average of 95% for missions noted on the Flight Planning Board manifest and launched pursuant to commercial launch service contracts.
Assessment				TBD

Define innovative human exploration mission approaches.

Explore the Space Frontier				2H4: Identify and evaluate candidate approaches for 100- to 1000- day human missions capable of a 5- to 10- fold cost reduction-- while increasing safety and effectiveness (compared to 1990s projections).
Assessment				TBD

Develop exploration/commercial capabilities through private sector and international partnerships.

	FY 1999	FY 2000	FY 2001	FY 2002
Explore the Space Frontier				2H5: Develop and test --on the ground and in space-- competing technologies for human missions beyond LEO in cooperation with international partners.
Assessment				TBD

Provide and make use of safe, affordable and improved access to space.

Enable Humans to live and Work Permanently in Space	9H15: Achieve seven or fewer flight anomalies per mission	0H12: Achieve seven or fewer flight anomalies per mission	1H7: Achieve 8 or fewer flight anomalies per mission.	2H6: Assure public, flight crew, and workforce safety for all Space Shuttle operations, measured by the following: • Achieve zero type A or B mishaps in FY 2002. • Achieve an average of 8 or fewer flight anomalies per Space Shuttle mission
Assessment	Green	Green	TBD	TBD
Enable Humans to live and Work Permanently in Space	9H16: Achieve 85% on time, successful launches, excluding weather risk.	0H13: Achieve 85% on time, successful launches, excluding weather risk. Changed to: Achieve 100% on-orbit mission success.	1H30: Achieve 100% on-orbit mission success	2H7: Safely meet the FY 2002 manifest and flight rate commitment. Annual performance goal is measured for Space Shuttle performance only.
Assessment	Yellow	Green		TBD
Enable Humans to live and Work Permanently in Space	9H17: Achieve a 13-month manifest preparation time.	0H14: Achieve a 12-month manifest preparation time.		2H8: Maintain a "12-month" manifest preparation time.
Assessment	Green	Green		TBD

Provide and make use of safe, affordable and improved access to space.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable Humans to live and Work Permanently in Space	9H18: Achieve a 60% increase in predicted reliability of Space Shuttle over 1995	0H15: Have in place an aggressive Shuttle program that ensures the availability of a safe and reliable Shuttle system through the ISS era.	1H6: Expedite a safety improvement program to ensure the continued safe operations of the Space Shuttle that ensures the availability of a safe and reliable Shuttle system to support Space Station Assembly milestones and operations.	2H09: Have in place a Shuttle safety investment program that ensures the availability of a safe and reliable Shuttle system for ISS assembly and operations.
Assessment	Green	Red	TBD	TBD

Operate the International Space Station to advance science, exploration, engineering and commerce.

Enable Humans to live and Work Permanently in Space		0H61: Conduct operations with a three-person human presence on the ISS.	1H12: Successfully complete the majority of combined ISS planned operations schedules and milestones as represented by permanent human on-orbit operations.	2H10: Demonstrate ISS on-orbit vehicle operational safety, reliability, and performance.
Assessment		Yellow	TBD	TBD
Enable Humans to live and Work Permanently in Space	9H42: Initiate full-scale Multi-Element Integration Testing (MEIT) for elements in the first four launch.		1H10: Successfully complete the majority of the planned development schedules and milestones required to support the Multi-element Integration Testing	2H11: Demonstrate ISS program progress and readiness at a level sufficient to show adequate readiness in the assembly schedule.
Assessment	Green		TBD	TBD

Operate the International Space Station to advance science, exploration, engineering and commerce.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable Humans to live and Work Permanently in Space	9H44: Conduct physical integration of the Z1 Truss launch package and initiate MEIT.			
Assessment	Green			

Operate the International Space Station to advance science, exploration, engineering and commerce.

Enable Humans to live and Work Permanently in Space	9H43: Deliver the U.S. laboratory module to the launch site in preparation for MEIT.	0H16: Deploy and activate the U.S. Laboratory Module to provide a permanent on orbit laboratory capability.		
Assessment	Green	Yellow		
Enable Humans to live and Work Permanently in Space	9H19: Deploy and activate the Russian-built Functional Cargo Block as the early propulsion and control module.	0H18: Deploy and activate the Airlock to provide an ISS-based EVA capability.	1H11: Successfully complete the majority of the ISS planned on-orbit activities such as delivery of mass to orbit and enhanced functionality.	2H12: Successfully complete 90% of the ISS planned mission objectives.
Assessment	Green	Yellow	TBD	TBD
Enable Humans to live and Work Permanently in Space	9H41: Deploy and activate the first U.S.-built element, Unity (Node 1), to provide docking locations and attach ports.	0H17: Deploy and activate the Canadian-built Space Station Remote Manipulator System to provide an ISS-based remote manipulating capability for maintenance and assembly.		
Assessment	Green	Yellow		

Operate the International Space Station to advance science, exploration, engineering and commerce.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable Humans to live and Work Permanently in Space		0H19: Deliver to orbit the first of three Italian-build Multi-Purpose Logistic Modules to provide a reusable capability for delivering payload and systems racks to orbit.		
Assessment		Yellow		
Enable Humans to live and Work Permanently in Space		0H20: Complete preparations for the initial ISS research capability through the integration of the first rack of the Human Research Facility (HRS-1), five EXPRESS racks with small payload research and the Microgravity Science Glovebox (MSG).	1H13: Successfully complete the majority of the planned research activities in support of initiation of on-orbit research opportunities	2H13: Demonstrate progress toward ISS research hardware development.
Assessment		Yellow	TBD	TBD
Enable Humans to live and Work Permanently in Space			1H14: Successfully complete no less than 85% of the planned Russian Program Assurance schedules and milestones required for the development of the Propulsion Module.	
Assessment			TBD	

Operate the International Space Station to advance science, exploration, engineering and commerce.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable Humans to live and Work Permanently in Space		0H22: Complete the production of the X-38 first space flight test article in preparation for a Shuttle test flight in 2001.	1H15: Successfully complete no less than 75% of the planned crew return capability schedules. FY01 indicators will include accomplishment of program schedule milestones for Phase 1 development Of a crew return vehicle (CRV) that could provide the U.S. crew return capability.	
Assessment		Yellow	TBD	

Ensure the health, safety and performance of humans living and working in space.

Enable Humans to live and Work Permanently in Space				2H14: Select and fund at least 3-5 proposals through the HTCI focused R&T program that feature: • Highly innovative new technology development efforts in selected areas associated with human safety and performance in space (e.g., Extravehicular Activity (EVA) systems)
Assessment				TBD

Meet sustained space operations needs while reducing costs.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable Humans to live and Work Permanently in Space	9H30: Complete the development of a commercialization plan for the ISS and the Space Shuttle in partnership with the research and commercial communities, and define and recommend policy and legislative changes.	0H39: Promote privatization of Space Shuttle operations and reduce civil service resource requirements for operations by 20% (from the FY 1996 FTE levels) in FY 2000.		
	Yellow	Red		
Enable Humans to live and Work Permanently in Space	9H34: Develop options and recommendations to commercialize space communications.	0H42: Increase the expenditures for commercial services to 10% of the total space communications budget by FY 2000.	1H20: Increase the percentage of the space operations budget allocated to acquisition of communications and data services from the commercial sector to 15%.	2H15: The Space Communications program will conduct tasks that enable commercialization and will minimize investment in government infrastructure for which commercial alternatives are being developed.
Assessment	Red	Green	TBD	TBD
Enable Humans to live and Work Permanently in Space		0H40: Promote privatization and commercialization of Space Shuttle payload operations through the transition of payload management functions (payload integration managers, payload officers, etc.) by FY 2000.	1H21: Achieve at least 95 percent of planned data delivery from space flight missions as documented in space, ground, deep space, and NASA integrated service networks performance metrics consistent with detailed program and project operations requirements in project service level agreements.	2H16: Performance metrics for each mission will be consistent with detailed program and project operations requirements in project Service Level Agreements • Achieve at least 95 percent of planned data delivery for space flight missions.
Assessment		Green	TBD	TBD

Meet sustained space operations needs while reducing costs.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable Humans to live and Work Permanently in Space		0H41: Within policy limitations and appropriate waivers, pursue the commercial marketing of Space Shuttle payloads by working to allow the Space Flight Operations Contractor to target two reimbursable flights, one in FY 2001 and one in FY 2002.		
Assessment		No longer applicable - see 2000 Performance Report		
Enable Humans to live and Work Permanently in Space	9H33: Reduce space communications operations costs by 30 to 35% compared to the FY96 budget, through a consolidated space communications contract to meet established budget targets.	0H43: Reduce the space communications budget submit for FY 2000 by 30-35% from the FY 1996 congressional budget submit.		
Assessment	Green	Green		

Improve the accessibility of space to meet the needs of commercial research and development.

Enable the Commercial Development of Space				2H17: Provide an average of five mid-deck lockers on each Space Shuttle mission to the International Space Station for research.
Assessment				TBD

Improve the accessibility of space to meet the needs of commercial research and development.

	FY 1999	FY 2000	FY 2001	FY 2002
Enable the Commercial Development of Space				2H18: Establish mechanisms to enable NASA access to the use of U.S. commercially developed launch systems.
Assessment				TBD

Foster commercial endeavors with the International Space Station and other assets.

Enable the Commercial Development of Space				2H19: Develop and execute a management plan and open future Station hardware and service procurements to innovation and cost-saving ideas through competition, including launch services and a Non-Government Organization for Space Station research.
Assessment				TBD

Develop new capabilities for human space flight and commercial applications through partnerships with the private sector

	FY 1999	FY 2000	FY 2001	FY 2002
Enable the Commercial Development of Space		0H44 Invest 25% of the space communications technology budget by FY 2000 in projects that could enable space commercial opportunities, including leveraging through a consortium of industry, academia, and Government.		
Assessment		Green		

Develop new capabilities for human space flight and commercial applications through partnerships with the private sector

	FY 1999	FY 2000	FY 2001	FY 2002
Enable the Commercial Development of Space			1H23: Foster commercial endeavors by reviewing and/or implementing new policies and plans, such as the Space Station resource pricing policy and intellectual property rights policy. Ensure that Space Station resources allocated to commercial research are utilized by commercial partners to develop commercial products and improve industrial processes.	
Assessment			TBD	
Enable the Commercial Development of Space				2H20: Conduct a competitive solicitation and selection process that will fund through the HEDS research and technology program HTCI (HEDS Technology and Commercialization Initiative): • Systems studies assessing the commercial potential associated with various prospective HEDS infrastructures/capabiliti es, • New technology development and demonstration efforts with potential longer-term commercial space value
Assessment				TBD

Develop new capabilities for human space flight and commercial applications through partnerships with the private sector

	FY 1999	FY 2000	FY 2001	FY 2002
Enable the Commercial Development of Space				2H21: Continue implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor.
Assessment				TBD

Engage and involve the public in the excitement and the benefits of ~~and~~ in setting the goals for ~~the~~ exploration and development of space.

	FY 1999	FY 2000	FY 2001	FY 2002
Share the Experience and Benefits of discovery				2H22: Competitively select and fund at least 5 activities to identify potential opportunities for high public value HEDS activities, including potential media access and/or public involvement in future HEDS missions.
Assessment				TBD

Provide significantly more value to significantly more people through exploration and space development efforts.

Share the Experience and Benefits of discovery				2H23: Establish a focused customer engagement process to significantly increase our value to significantly more people by enabling the public to guide the formulation of HEDS goals, objectives, programs and missions.
Assessment				TBD

Provide significantly more value to significantly more people through exploration and space development efforts.

	FY 1999	FY 2000	FY 2001	FY 2002
Share the Experience and Benefits of discovery				2H24: Expand public access to HEDS missions information (especially ISS) by working with industry to create media projects and public engagement initiatives that allow "first-hand" public participation using telepresence for current missions, and virtual reality or mock-ups for future missions beyond Earth orbit.
				TBD

Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

	FY 1999	FY 2000	FY 2001	FY 2002
Share the Experience and Benefits of discovery				2H25: Establish initial partnerships with educators at all levels (K-12 and universities) in order to increase the involvement of faculty and students in HEDS.
Assessment				TBD

Human Exploration and Development of Space FY 2002	**Budget Category**	Advanced Programs	Expendable Launch Vehicles and Payloads	Space Communications	Space Shuttle	Space Station
Annual Performance Goal						
2H1: Begin the development of high-leverage technologies to enable safe, effective and affordable human/robotic exploration missions beyond LEO.		X				
2H2: Test at the International Space Station competing technologies for human missions beyond LEO, in cooperation with other agencies and international partners, and with US industry.						X
2H3: Provide reliable launch services for approved missions.			X			
2H4: Identify and evaluate candidate approaches for 100- to 1000- day human missions capable of a 5- to 10- fold cost reduction--while increasing safety and effectiveness (compared to 1990s projections).		X				
2H5: Develop and test --on the ground and in space-- competing technologies for human missions beyond LEO in cooperation with international partners.		X				
2H6: Assure public, flight crew, and workforce safety for all Space Shuttle operations, measured by the following: • Achieve zero type A or B mishaps in FY 2002. • Achieve an average of 8 or fewer flight anomalies per Space Shuttle mission					X	
2H7: Safely meet the FY 2002 manifest and flight rate commitment. Annual performance goal is measured for Space Shuttle performance only.					X	
2H8: Maintain a "12-month" manifest preparation time.			X			

Human Exploration and Development of Space FY 2002	**Budget Category**	Advanced Programs	Expendable Launch Vehicles and Payloads	Space Communications	Space Shuttle	Space Station
Annual Performance Goal						
2H9: Have in place a Shuttle safety investment program that ensures the availability of a safe and reliable Shuttle system for ISS assembly and operations.					X	
2H10: Demonstrate ISS on-orbit vehicle operational safety, reliability, and performance.						X
2H11: Demonstrate ISS program progress and readiness at a level sufficient to show adequate readiness in the assembly schedule.						X
2H12: Successfully complete 90% of the ISS planned mission objectives.						X
2H13: Demonstrate progress toward ISS research hardware development.						X
2H14: Select and fund at least 3-5 proposals through the HTCI focused R&T program that feature: o Highly innovative new technology development efforts in selected areas associated with human safety and performance in space (e.g., Extravehicular Activity (EVA) systems)		X				
2H15: The Space Communications program will conduct tasks that enable commercialization and will minimize investment in government infrastructure for which commercial alternatives are being developed.				X		
2H16: Performance metrics for each mission will be consistent with detailed program and project operations requirements in project Service Level Agreements				X		

Human Exploration and Development of Space FY 2002	**Budget Category**	Advanced Programs	Expendable Launch Vehicles and Payloads	Space Communications	Space Shuttle	Space Station
Annual Performance Goal						
2H17: Provide an average of five mid-deck lockers on each Space Shuttle mission to the International Space Station for research.						X
2H18: Establish mechanisms to enable NASA access to the use of U.S. commercially developed launch systems.			X			
2H19: Develop and execute a management plan and open future Station hardware and service procurements to innovation and cost-saving ideas through competition, including launch services and a Non-Government Organization for Space Station research.						X
2H20: Conduct a competitive solicitation and selection process that will fund through the HEDS research and technology (R&T) program HTCI (HEDS Technology and Commercialization Initiative): o Systems studies assessing the commercial potential associated with various prospective HEDS infrastructures/capabilities, o New technology development and demonstration efforts with potential longer-term commercial space value.		X				
2H21: Continue implementation of planned and new privatization efforts through the Space Shuttle prime contract and further efforts to safely and effectively transfer civil service positions and responsibilities to the Space Shuttle contractor.					X	

Human Exploration and Development of Space FY 2002	**Budget Category**	Advanced Programs	Expendable Launch Vehicles and Payloads	Space Communications	Space Shuttle	Space Station
Annual Performance Goal						
2H22: Competitively select and fund at least 5 activities to identify potential opportunities for high public value HEDS activities, including potential media access and/or public involvement in future HEDS missions.		X				
2H23: Establish a focused customer engagement process to significantly increase our value to significantly more people by enabling the public to guide the formulation of HEDS goals, objectives, programs and missions.		X				
2H24: Expand public access to HEDS missions information (especially ISS) by working with industry to create media projects and public engagement initiatives that allow "first-hand" public participation using telepresence for current missions, and virtual reality or mock-ups for future missions beyond Earth orbit.						X
2H25: Establish initial partnerships with educators at all levels (K-12 and universities) in order to increase the involvement of faculty and students in HEDS.		X				

Aerospace Technology Enterprise

Mission

The Aerospace Technology (AST) Enterprise mission is to pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aerospace technologies. Research and development programs conducted by the Enterprise contribute to NASA's science and exploration mission, national security, economic growth, and the competitiveness of American aerospace companies. The Enterprise plays a key role in maintaining a safe and efficient national aviation system and enabling an affordable, reliable space transportation system. The Enterprise directly supports national policy in both aeronautics and space as directed in the President's Goals for a National Partnership in Aeronautics and Research Technology, the National Space Policy, and the National Space Transportation Policy.

Implementation Strategy

The Enterprise manages a clearly defined portfolio of technology investments to ensure alignment with national policy, Agency goals, customer requirements, and budget availability. The investment strategies are focused on issues associated with future aviation and space systems. Enterprise objectives are outcome-focused and "stretch" beyond our current knowledge base. The outcome-focused nature of the objectives projects a preferred end-state within the air and space transportation systems. Designated Lead Centers have been assigned the responsibility to manage the implementation and execution phases of the technology programs. Enterprise programs are often conducted in cooperation with other Federal agencies, primarily the Federal Aviation Administration and the Department of Defense. These partnerships take advantage of the national investment in aeronautics and astronautics capabilities and eliminate unnecessary duplication.

The Enterprise supports the maturation of technology to a level such that it can be confidently integrated into current and new systems. In most cases, technologies developed by the Enterprise can be directly transferred to the external customer.

Enterprise Resource Requirements

The President has requested the following budget for FY 1999 to FY 2002 to support the accomplishment of AST goals:

	FY 1999	FY 2000	FY 2001	FY 2002
NOA $M	1,338.9	1,266.7	1404.1	1508.0
CS FTE	4,227	4,345	4,713	4,710

Performance Metrics

Goal: Revolutionize Aviation – Enable the safe, environmentally-friendly expansion of aviation.

Objective: Increase Safety – Make a safe air transportation system even safer.

Public Benefit: Improved safety of air travel

Performance Goal 2R1: Complete the interim progress assessment utilizing the technology products of the Aviation Safety program as well as the related Aerospace Base R&T efforts and transfer to industry an icing CD-ROM, conduct at least one demonstration of an aviation safety related subsystem, and develop at least two-thirds of the planned models and simulations. Planned program products that support the accomplishment of the annual performance goal are:

Aerospace Focused – Aviation Safety

- Complete a GA pilot survey.
- Conduct a fast-time simulation of system-wide risks.
- Model high error probability contexts and solutions.
- Demonstrate loss of control and recovery models.
- Flight demonstrate forward-looking turbulence warning systems.
- Demonstrate a National Aviation Weather Information Network (AWIN) capability.
- Demonstrate a national AWIN data link capability.
- Validate structural crash analysis tools.
- Complete an interim integrated program assessment.

Aerospace Base R&T

- Develop and distribute a CD-ROM self-paced icing training modules for pilots.
- Develop a methodology for the design and verification of task driven human automation systems.
- Complete validation of new perceptual measurement tools for evaluating display effectiveness as it supports human performance.
- Generate initial model for flight crew Scheduling Assistant based on sleep and circadian cycles.
- Demonstrate prototype technologies for an aviation safety information system
- Assess the electromagnetic impact on critical flight control hardware through physics-based modeling of the Electromagnetic (EM) fields.
- Develop the methodology for improved radiographic inspection of complex structures with scanned x-ray source and multiple detectors to enable improved characterization of aerospace structures and detection of flaws critical to safety and reliability.

Objective: Reduce Emissions -- Protect local air quality and our global climate.

Public Benefit: Improved air quality and protection of the environment

Annual Performance Goal 2R2: NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen (NOx) and carbon dioxide (CO_2). The annual performance goal is to complete sector testing of a low-NOx combustor concept capable of a 70% reduction in NOx from the 1996 [International Civil Aviation Organization (ICAO)] baseline, and demonstrate at least one additional concept for the reduction of other emittants. Planned program products that support the accomplishment of the annual performance goal are:

Aerospace Focused – Ultra-Efficient Engine Technology

- Complete sector evaluations of a combustor capable of 70% reductions in Oxides of Nitrogen.
- Select ceramic thermal barrier coating/process
- Demonstrate aspirating seal technology
- Develop an Integrated Component Demonstration Plan for collaborative tests of engine demonstrators incorporating UEET technologies for large and small thrust class engines.

Aerospace Base R&T

- Assess hybrid fuel cell and liquid hydrogen fueled optimized turbofan concepts.
- Demonstrate concepts for reduction in gaseous, particulate, and aerosol emissions.
- Identify revolutionary aeropropulsion concepts identified and assess preliminary performance .

Objective: Reduce Noise – Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers.

Public Benefit: Improved noise environment in communities near airports

Annual Performance Goal 2R3: NASA's research stresses reducing noise in the areas of engines, nacelles, engine-airframe integration, aircraft interiors and flight procedures. The annual performance goal is to assess and establish the strongest candidate technologies to meet the 10-decibel reduction in community noise. Planned program products that support the accomplishment of the annual performance goal are:

Aerospace Focused – Quiet Aircraft Technology

- Identify community noise impact reduction technology required to meet 10 year, 10 decibel Enterprise goal.
- Deliver initial version of improved aircraft systems noise prediction code delivered

Objective: Increase Capacity -- Enable the movement of more air passengers with fewer delays.

Public Benefit: Reduced travel time, improved use of natural resources, and protection of the environment

Annual Performance Goal 2R4: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The annual performance goal is to develop at least two decision support tools for arrival, surface, and departure operations, and define requirements for future aviation system concepts. Planned program products that support the accomplishment of the annual performance goal are:

<u>Aerospace Focused – Aviation System Capacity</u>

- Develop and evaluate inter-operability of decision support tools that address arrival, surface and departure operations.
- Develop and evaluate a traffic flow management decision support tool for system-wide prediction of sector loading.
- Develop, demonstrate initial functionality, and evaluate human factors for active terminal area decision support tool.

<u>Aerospace Base R&T</u>

- Define and document the requirements for a high-fidelity, real-time, human-in-the-loop simulation system to evaluate proposed aviation system concepts.
- Define and document a concept for the future aviation system as the basis for future modeling.
- Complete the Critical Design Review for the Blended Wing Body experimental vehicle.

Objective: Increase Mobility – Enable people to travel faster and farther, anywhere, anytime.

Public Benefit: Increased destinations reachable by air and reduced travel time

Annual Performance Goal 2R5: NASA's research stresses aircraft technologies which enable the use of existing small community and neighborhood airports, without requiring control towers, radar installations, and more land use for added runway protection zones. The annual performance goal is to baseline in partnership with the FAA, the system engineering documents for the Small Aircraft Transportation System concept. Planned program products that support the accomplishment of the annual performance goal are:

<u>Aerospace Focused – Small Aircraft Transportation System</u>

- Complete preparation of the baseline System Engineering documents (including the Operational Requirements Document, Functional Architecture, and Technical Requirements Document) for SATS concept and place under configuration management.

<u>Aerospace Base R&T</u>

- Complete preliminary design of extremely slow takeoff and landing vehicle.

Goal: Advance Space Transportation — Create a safe, affordable highway through the air and into space.

Objective: Mission Safety -- Radically improve the safety and reliability of space launch systems.

Public Benefit: Expanded opportunities for near-Earth operations and commercialization through safe and reliable access to space

Annual Performance Goal 2R6: NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews to support design and demonstration decisions. Planned program products that support the accomplishment of the annual performance goal are:

Aerospace Focused – 2nd Generation RLV

- Conduct Risk Reduction Review.
- Conduct Interim Architecture Review to establish the candidate space transportation architectures.

Objective: Mission Affordability – Create an affordable highway to space.

Public Benefit: Expanded opportunities for near-Earth operations and commercialization through affordable access to space

Annual Performance Goal 2R7**:** NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews and initial hardware demonstrations to support design and demonstration decisions. Planned program products that support the accomplishment of the annual performance goal are:

Aerospace Focused – 2nd Generation RLV

- Conduct Risk Reduction Review.
- Conduct Interim Architecture Review to establish the candidate space transportation architectures.

Aerospace Base R&T

- Demonstrate PDE-based combined/ hybrid cycle feasibility and baseline performance levels.
- Demonstrate advanced adhesives for non-autoclave composite processing.
- Complete Systems Requirements Review on Rocket Based Combined Cycle Demonstrator Engine.
- Demonstrate Reaction Transfer Molded Polymer Matrix Composite with 550°F use temperature.
- Conduct 2nd Mach 7 flight of the X-43 (Hyper-X).

- Conduct 1st Mach 10 flight of the X-43 (Hyper-X).

Objective: Mission Reach – Extend our reach in space with faster travel times.

Public Benefit: Expanded knowledge of the universe and its meaning to life on Earth

Annual Performance Goal 2R8: NASA's long term research emphasizes innovative propulsions systems. The annual performance goal is to conduct at least one electric propulsion test. Planned program products that support the accomplishment of the annual performance goal are:

<u>Aerospace Base R&T</u>
- Complete integration and wear test of 8 cm ion engineering model thruster and breadboard Power Processing Unit.
- Conduct integration test of 5-kW PPU with 5/10 kW next-generation ion engine.

Goal: Pioneer Technology Innovation — Enable a revolution in aerospace systems.

Objective: Engineering Innovation -- Enable rapid, high-confidence, and cost efficient design of revolutionary systems.

Public Benefit: Improved productivity of American aerospace workers and their contribution to the national economy

Annual Performance Goal 2R9: NASA's investments emphasize advances in experimental vehicles, flight testbeds, and computing tools to enable revolutionary designs. The annual performance goal is to conduct at least five demonstrations of revolutionary aerospace subsystems. Planned program products that support the accomplishment of the annual performance goal are:

<u>Aerospace Base R&T</u>
- Develop prototype environments that are distributed across heterogeneous platforms, are dynamically extensible, and which support collaborative visualization, analysis, and computational steering.
- Demonstrate improvement in time-to-solution for aerospace applications through high-end computing and end-to-end networking capabilities.
- Develop capability to redesign aerospace vehicles during flight simulations exploiting high-end computing and advanced information management technologies.
- Demonstrate a prototype of a reliability and cost database of space transportation and exploration system mission failures including the definition of the appropriate taxonomy.
- Demonstrate a highly integrated simulation environment that facilitates the rapid development of future generation electronic devices for PetaFLOPS computing and onboard computing systems for autonomous intelligent vehicles.
- Demonstrate, in production facilities, tools and techniques for high-productivity aerospace test environment.
- Demonstrate automated software verification technology that scales to aerospace software systems.

- Develop system for real-time data acquisition and display of disparate instrumentation types.
- Integrate and demonstrate a Intelligent Flight Control (IFC) into a C-17 simulation.
- Integrate and test at least 4 flight experiments on the F-15B testbed aircraft
- Demonstrate turbo-prop remotely piloted aircraft (RPA) capabilities that exceed the minimum Earth Science Enterprise altitude and duration requirements.
- Demonstrate a Viscous, solution-adaptive, unstructured-grid Computational Fluid Dynamics (CFD).
- Develop conceptual high-level autonomy rover architecture.
- Complete a Mars Mission Software Verification Study
- Complete a case study demonstrating software verification and validation techniques that are applicable to Mars mission software.
- Apply human-centered computing analysis and modeling techniques to evaluate and improve the Mars Exploration Rover (MER) 2003 flight team man-machine system performance for operations and science.

Objective: Technology Innovation -- Enable fundamentally new aerospace system capabilities and missions.

Public Benefit: Continued U.S. competitiveness in the global marketplace, and quality of life from new discoveries

Annual Performance Goal 2R10: NASA's investments emphasize revolutionary technologies such as nanotechnology, information technology and biotechnology that could enable new missions and capabilities. The annual performance goal is to develop at least two new materials concepts and demonstrate the feasibility of at least two nanotechnology and two other concepts. Planned program products that support the accomplishment of the annual performance goal are:

Aerospace Base R&T

- Demonstrate feasibility of nanotechnology-based chemical and biosensors and manufacturing approaches of low-power nanoelectronic components.
- Complete initial integrated concept study to assess adaptive vehicle control
- Demonstrate aligned carbon nanotubes for polymer matrix material.
- Develop and demonstrate in flight next generation neural flight control
- Demonstrate oscillatory flow control actuators
- Demonstration of Space Communication Link Technology Operating at 622 Mega-bit per second for Direct Space Data Distribution to Users.
- Demonstrate the methodology to produce physics based scaling laws to quantify Reynolds number sensitivities of aerodynamic flow separation on-set and progression.
- Demonstrate the ability to dynamically alter the localized flow instabilities over advanced lifting surfaces with micro-adaptive flow control devices.
- Develop concepts for design and analyses of algorithms for control of colonies of fluidic flow control effectors.

- Develop concepts for non-deterministic analyses of advanced composites. including nanotube reinforced polymers to characterize processing uncertainties on material properties.
- Develop concepts for advance sensory materials development and methodologies for imbedding sensors into aerospace structural materials.

Goal: Commercialize Technology — Extend the commercial application of NASA technology for economic benefit and improved quality of life.

Objective: Commercialization — Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry.

Public Benefit: Quality of life from direct aerospace contributions to the U.S. economy, as well as indirect contributions to the fields of medicine and education

Annual Performance Goal 2P7: Dedicate 10 to 20 percent of the Agency's Research and development budget to commercial partnerships. (as noted, this goal is presented in the Provide Aerospace Products and Capabilities section of the plan since it crosscuts all NASA Enterprises)

Annual Performance Goal 2R11: Continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.

- Achieve a facility utilization customer satisfaction rating of 95 percent at "5" or better using a "10" point scale, and 80 percent "8" or better, based on exit interviews.
- Transfer at least twelve new technologies and processes to industry and other government agencies during the fiscal year.

Annual Performance Goal 2R12: Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2002.

- Implementation examples from current education outreach plans.
- Documented plans for all new program activities initiated in FY 2002

Goal: Space Transportation Management — Provide commercial industry with the opportunity to meet NASA's future launch needs, including human access to space, with new launch vehicles that promise to dramatically reduce cost and improve safety and reliability. (Supports all objectives under the Advance Space Transportation Goal.

Objective: Utilize NASA's Space Transportation Council (STC) in combination with an External Independent Review Team (EIRT) to assure agency-level integration of near and far-term space transportation investments.

Public Benefit: Improved assurance that commercial capabilities and opportunities are appropriately examined in planning and developing new launch vehicle systems

Annual Performance Goal 2R13: Review results of NASA and commercial-sector performed launch system architecture studies, related requirements, and refinements in planned risk-reduction investments.

- Complete an assessment of the Space Launch Initiative architectures and requirements by an External Independent Review Team; the EIRT will submit a written report on their evaluation within 45 days following completion of the review.

- The Space Transportation Council will review progress and planning of the Space Launch Initiative at least twice during the fiscal year, including the report filed by the External Independent Review Team.

Addressing Technology Management Challenges

The overall organizational and management structure of NASA technology development is built around its Strategic Enterprises, including specific program formulation and funding responsibility for all technology activities. This ensures that technology considerations are closely coupled with mission decisions, that technologies are relevant to Enterprise needs, and that mechanisms are provided to transfer successful maturing technologies into operational systems. NASA has undertaken sweeping changes in technology program management to strengthen and highlight the significance of advanced technology in NASA's future. These changes influence how NASA identifies new technology investments, how NASA defines new mission opportunities, and how NASA ensures the efficient transition of new technologies into missions. Overall, the adjustments have resulted in a closer alignment of technology investments with the goals identified in the NASA Strategic Plan.

Coordination and integration among all of the Agency's Enterprises is provided through the NASA Chief Technologist. The Chief Technologist advises the Administrator and other senior officials on matters relating to technology, assures an Agency-wide investment strategy for advanced innovative technology, and is the principal Agency advocate for advanced technology. The Chief Technologist also chairs the Technology Leadership Council, which includes the Associate Administrators for the Strategic Enterprises, the NASA Field Center Directors, the NASA Comptroller, and other senior NASA officials. This Council establishes the technology strategy for the Agency, addresses critical issues, and is responsible for formulating and advancing NASA's vision for technology.

This integrated planning process for technology development is described in detail in the NASA Technology Plan, and reviewed by the Technology and Commercialization Advisory Committee (TCAC), a standing committee of the NASA Advisory Council. The TCAC advises NASA on broad, Agency-wide issues associated with technology and commercialization activities. In addition, each Enterprise supports an advisory committee that is part of the NASA Advisory Council to review its programs and provide recommendations for improvement. These advisory committees include technologists or, in some cases, technology subcommittees to provide special focus on technology activities.

In February 2000, the NASA Administrator merged the Chief Technologist's Office with the Office of Aerospace Technology to better focus the Agency's strategy for maintaining its long-term technology base. The NASA Chief Technologist retains responsibility for serving as the Administrator's principal advisor on Agency-wide technology issues, while also serving as the Associate Administrator for Aerospace Technology. This merger centralized planning and execution of Agency-level technology within one organization while still providing for Enterprise-specific mission technology development by each of the other NASA Enterprises.

Verification/Validation

The Aerospace Technology Enterprise regularly reviews its progress on achieving its performance targets using NASA's established policies and procedures for program and project management. Internal evaluation is provided by the governing Program Management Council, either at the Agency-level or at the designated Lead Center, which meet at least quarterly to execute their oversight responsibilities. The AST Enterprise also relies on the extensive Safety, Quality, and Reliability processes and Center organizations to assure that performance in our facilities is maintained to standards appropriate for research and technology development operations.

The Aerospace Technology Committee of the NASA Advisory Council also conducts annual assessments of the progress made by the AST Enterprise in achieving its near-term technology objectives. This committee, and its nine technical subcommittees consisting of nearly 150 members from other government agencies, industry and academia that meet two to three times a year, will provide a qualitative progress measurement (Green, Yellow, or Red). "Green" will indicate that the objective was met; "Yellow" will indicate a concern that an objective was not fully accomplished; and "Red" will indicate that events occurred that prevented or severely impaired the accomplishment of the objective. This external assessment includes commentary to clarify and supplement the qualitative measures.

MULTI-YEAR PERFORMANCE TREND

Aerospace Technology Enterprise (OAT)

Increase Safety – Make a safe air transportation system even safer.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	9R5: For the aviation safety areas of Controlled Flight into Terrain, runway incursion, and loss of control, identify the contributing causes to be addressed, potential solutions using current capabilities, and gaps that require technology solutions.	'0R3: Flight demonstrate a conceptual aircraft flight deck integrated with evolving ground-based runway incursion avoidance technologies installed at a major airport..	1R1: NASA's research stresses aviation system monitoring and modeling, accident prevention and accident mitigation. The performance target is to complete 75% of the conceptual designs of systems for preventing and mitigating accidents, and to demonstrate tools for accident analysis and risk assessment.	2R1: NASA's research stresses aviation system monitoring and modeling, accident prevention, and accident mitigation. The annual performance goal is to complete the interim progress assessment utilizing the technology products of the Aviation Safety program as well as the related Aerospace Base R&T efforts and transfer to industry an icing CD-ROM, conduct at least one demonstration of an aviation safety related subsystem, and develop at least two-thirds of the planned models and simulations.
Assessment	Green	Yellow	TBD	TBD
Annual Performance Goal and APG #	9R2: Characterize the Super-cooled Large Droplets (SLD) icing environment, determine its effects on aircraft performance, and acquire and publish data to improve SLD forecasting confidence.			
Assessment	Yellow		TBD	TBD

Reduce Emissions -- Protect local air quality and our global climate.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9R1: Demonstrate an advanced turbine-engine combustor that will achieve up to a 50 percent reduction of Oxides of Nitrogen emissions based on 1996 International Civil Aviation Organization (ICAO) standards.	0R1: Demonstrate, in a laboratory combustion experiment, an advanced turbine-engine combustor concept that will achieve up to a 70% reduction of oxides of nitrogen emissions based on the 1996 ICAO standard.	1R2: NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen and carbon dioxide. The performance target is to complete one system level technology benefit assessment, one component concept selection and one new material system.	2R2: NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen (NOx) and carbon dioxide (CO2). The annual performance goal is to complete sector testing of a low-NOx combustor concept capable of a 70% reduction in NOx from the 1996 International Civil Aviation Organization (ICAO) baseline, and demonstrate at least one additional concept for the reduction of other emittants.
Assessment	Green	Blue	TBD	TBD

Reduce Noise – Reduce aircraft noise to benefit airport neighbors, the aviation industry, and travelers.

Annual Performance Goal and APG #		0R2: Validate the technologies to reduce noise for large commercial transports by at least 7 decibels relative to 1992 production technology.	1R3: NASA's research has stressed reducing noise in the areas of engines, nacelles, engine/airframe integration, aircraft interiors and flight procedures. The performance target is completion of NASA's research in noise reduction through large-scale demonstration of a 2-5 decibel reduction in aircraft noise based on 1997 production technology, and initial assessments of concepts offering additional reduction.	2R3: NASA's research stresses reducing noise in the areas of engines, nacelles, engine-airframe integration, aircraft interiors and flight procedures. The annual performance goal is to assess and establish the strongest candidate technologies to meet the 10-decibel reduction in community noise.
Assessment		Green	TBD	TBD

Increase Capacity -- Enable the movement of more air passengers with fewer delays.

Annual Performance Goal and APG #		0R4: Conclude the Terminal Area Productivity project by field demonstrations of the complete suite of technologies and procedures that enable a 12% increase over 1994 nonvisual operations for single-runway throughput.	1R4: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The performance target is to complete the civil tiltrotor project by validating databases for contingency power, flight paths, and noise reduction, as well as complete at least one demonstration of an airspace management decision support tool.	2R4: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The annual performance goal is to demonstrate at least two decision support tools for arrival, surface, and departure operations, and define requirements for future aviation system concepts.
Assessment		Green	TBD	TBD

Increase Mobility – Enable people to travel faster and farther, anywhere, anytime.

Annual Performance Goal and APG #	9R8: Conclude pre-flight ground testing of the general aviation piston and turbofan engines.	0R7: Perform flight demonstrations of advanced general aviation piston and turbine engines at the annual Oshkosh air show.	1R7: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The performance target is to complete the Advanced General Aviation Transport Experiments project by validating transportation system concepts through flight test and publish design guidelines.	2R5: NASA's research stresses aircraft technologies which enable the use of existing small community and neighborhood airports, without requiring control towers, radar installations, and more land use for added runway protection zones. The annual performance goal is to baseline in partnership with the FAA the system engineering documents for the Small Aircraft Transportation System concept.
Assessment	Yellow	Yellow	TBD	TBD

Increase Mobility – Enable people to travel faster and farther, anywhere, anytime.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9R6: Produce a complete vehicle system configuration document that includes impact of technology validation efforts from 1990 through 1999. This document will support the evaluation of technology selection decisions for a future High Speed Civil Transport (HSCT).			
Assessment	Green			

Mission Safety -- Radically improve the safety and reliability of space launch systems.

Annual Performance Goal and APG #				2R6: NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews to support design and demonstration decisions.
Assessment				TBD

Mission Affordability – Create an affordable highway to space.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	9R14: Continue the X-33 Vehicle Assembly in Preparation for Flight Testing.	0R9: Conduct the flight testing of the X-33 vehicle.	1R10: NASA's research stresses highly reliable, fully reusable configurations, advanced materials and innovative structures. The performance target is complete assembly of the third X-34 test vehicle, demonstrate 75% of supporting technology developments, and complete competitive solicitations for expanded 2nd generation reusable launch vehicle efforts.	2R7: NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews and initial hardware demonstrations to support design and demonstration decisions.
Assessment	Green	Red	TBD	TBD
Annual Performance Goal and APG #	9R15: Complete Vehicle Assembly and Begin Flight Testing of the X-34.	0R12: Complete vehicle assembly and begin the flight test of the second X-34 vehicle.	1R11: NASA's research stresses technology for reusable, long life, high power electric and advanced, clean chemical engines for earth orbital transfer and breakthrough propulsion, precision landing systems and aero-capture systems for planetary exploration. The performance target is to commence X-37 vehicle assembly, and complete one Pathfinder flight experiment.	
Assessment	Yellow	Red	TBD	

Mission Affordability – Create an affordable highway to space.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0R17: Complete small payload focused technologies and select concepts for flight demonstration of a reusable first stage (Bantam).		
Assessment		Red (project terminated 10/99)		

Mission Reach – Extend our reach in space with faster travel times.

Annual Performance Goal and APG #		0R10: Complete NASA Solar Electric Propulsion Technology Application Readiness (NSTAR) Mission Profile (100% design life) ground testing for Deep Space-1 (concurrent, identical firing of an NSTAR engine in a vacuum chamber with the actual firing sequence of the in-flight propulsion system).		2R8: NASA's long term research emphasizes innovative propulsion systems. The performance target is to conduct at least one electric propulsion test.
Assessment		Green		TBD

Engineering Innovation -- Enable rapid, high-confidence, and cost efficient design of revolutionary systems.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9R12: Demonstrate up to a 200-fold improvement over the 1992 baseline (reduction from 3,200 hours to 15) in the time-to-solution for a full combustor simulation on NASA's National Propulsion System Simulation advanced applications computational testbeds that can be increased to sustain teraFLOPS capability.	0R8: Demonstrate a prototype heterogeneous distributed computing environment.	1R8: Develop at least three new design tools, accomplish at least four demonstrations of advances in computation and communications, and complete the intelligent synthesis environment proof-of-concept system capability build to technology readiness level 3.	2R9: NASA's investments emphasize advances in experimental vehicles, flight testbeds, and computing tools to enable revolutionary designs. The annual performance goal is to conduct at least five demonstrations of revolutionary aerospace subsystems.
Assessment	Blue	Green	TBD	TBD
Annual Performance Goal and APG #	9R13: Demonstrate communication testbeds with up to 500-fold improvement over the 1996 baseline (increase from 300 kilobits per second to 150 megabits per second) in end-to-end performance.			
Assessment	Blue			

Engineering Innovation -- Enable rapid, high-confidence, and cost efficient design of revolutionary aerospace systems.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9R10: Complete low-altitude flights of an Remotely Piloted Aircraft (RPA) with a wingspan greater than 200 feet, suitable for flight to 100,000 feet in altitude once outfitted with high-performance solar cells.	0R11: Demonstrate improved remotely piloted aircraft science mission capability by increasing operational deployment time from 3 weeks to 9 with minimum airfield provisions and unrestricted airspace. (Original) Demonstrate continuous over-the-horizon command and control capabilities of an RPA that would extend the operating range from 40 to 200 nautical miles. (Replacement)		
Assessment	Green	Red (orig.); Green (replacement)		
Annual Performance Goal and APG #	9R11: Conduct RPA flight demonstration to validate the capability for science missions of greater than 4 hours duration in remote deployments to areas such as the polar regions above 55,000 feet.			
Assessment	Green			

Engineering Innovation -- Enable rapid, high-confidence, and cost efficient design of revolutionary aerospace systems.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0R6: Demonstrate in flight an airframe-integrated, dual-mode, scramjet-powered vehicle.	1R9: NASA's research stresses affordable flight demonstrations of revolutionary vehicle concepts (low-cost X-Planes) to accelerate technology advances in laboratory research, new design tools and advanced simulation. The performance target is to demonstrate two new concepts in flight and identify five new concepts for further examination.	
Assessment		Yellow	TBD	

Technology Innovation -- Enable fundamentally new aerospace system capabilities and missions.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2R10: NASA's investments emphasize revolutionary technologies such as nanotechnology, information technology and biotechnology which could enable new missions and capabilities. The annual performance goal is to develop at least two new materials concepts and demonstrate the feasibility of at least two nanotechnology and two other concepts.
Assessment				TBD

Commercialization — Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9R16: Complete 90 percent of all Enterprise-controlled milestones within 3 months of schedule.	0R13: Complete 90 percent of all Enterprise-controlled milestones within 3 months of schedule.		
Assessment	Yellow	Red		
Annual Performance Goal and APG #	9R17: Achieve a facility utilization customer satisfaction rating of 95 percent of respondents at "5" or better and 80 percent at "8" or better based on exit interviews.	0R14: Achieve a facility utilization customer satisfaction rating of 95% of respondents at "5" or better and 80% at "8" or better, based on exit interviews.		
Assessment	Blue	Green		
Annual Performance Goal and APG #	9R18: Complete the Triennial Customer Satisfaction Survey, and achieve an improvement from 30 percent to 35 percent in "highly satisfied" ratings from Enterprise customers.		1R12: Customer Feedback: Continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.	2R11: Continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.
Assessment	Green		TBD	TBD
Annual Performance Goal and APG #	9R19: Transfer at least 10 new technologies and processes to industry during the fiscal year.	0R15: Transfer at least 12 new technologies and processes to industry during the fiscal year.		
Assessment	Blue	Blue		

Commercialization — Facilitate the greatest practical utilization of NASA know-how and physical assets by U.S. industry.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	9R21: For all new program activities initiated in FY 99, develop an education outreach plan, which includes and results in an educational product. This product shall be consistent with current educational standards and use program content to demonstrate or enhance the learning objectives.	0R16: Continue the implementation of current education outreach plans and establish new plans for all new program activities initiated in FY 00.	1R13: Education Outreach: Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2001.	2R12: Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2002.
Assessment	Yellow	Blue	TBD	TBD
Annual Performance Goal and APG #	9R20: Establish an Aeronautics Education Laboratory in at least three new sites in the United States.			
Assessment	Blue			

Utilize NASA's Space Transportation Council (STC) in combination with an External Independent Review Team (EIRT) to assure agency-level integration of near and far-term space transportation investments.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #				2R13: Review results of NASA and commercial-sector performed launch system architecture studies, related requirements, and refinements in planned risk-reduction investments.
Assessment				TBD

Aerospace Technology Enterprise FY2002		AEROSPACE FOCUSED						AEROSPACE BASE R&T					
	Budget Category	Aviation System Capacity	Aviation Safety Technology	Ultra-Efficient Engine Technology	Small Aircraft Transportation System	Quiet Aircraft Technology	2nd Generation RLV	Aero-Space Base R&T -- Computing, Information & Communication Technology	Aero-Space Base R&T -- Flight Research	Aero-Space Base R&T -- Propulsion & Power	Aero-Space Base R&T -- Vehicle System Technology	Aero-Space Base R&T -- Space Transfer & Launch Tech.	R&PM
Annual Performance Goal													
2R1: NASA's research stresses aviation system monitoring and modeling, accident prevention, and accident mitigation. The annual performance goal is to complete the interim progress assessment utilizing the technology products of the Aviation Safety program as well as the related Aerospace Base R&T efforts and transfer to industry an icing CD-ROM, conduct at least one demonstration of an aviation safety related subsystem, and develop at least two-thirds of the planned models and simulations.			X					X		X	X		X
2R2: NASA's research stresses engine technology to reduce the emissions of oxides of nitrogen (NOx) and carbon dioxide (CO2). The annual performance goal is to complete sector testing of a low-NOx combustor concept capable of a 70% reduction in NOx from the 1996 International Civil Aviation Organization (ICAO) baseline, and demonstrate at least one additional concept for the reduction of other emittants.				X						X	X		X

Aerospace Technology Enterprise FY2002		AEROSPACE FOCUSED						AEROSPACE BASE R&T						
	Budget Category	Aviation System Capacity	Aviation Safety Technology	Ultra-Efficient Engine Technology	Small Aircraft Transportation System	Quiet Aircraft Technology	2nd Generation RLV	Aero-Space Base R&T -- Computing, Information & Communication Technology	Aero-Space Base R&T -- Flight Research	Aero-Space Base R&T -- Propulsion & Power	Aero-Space Base R&T -- Vehicle System Technology	Aero-Space Base R&T -- Space Transfer & Launch Tech.	R&PM
Annual Performance Goal													
2R3: NASA's research stresses reducing noise in the areas of engines, nacelles, engine-airframe integration, aircraft interiors and flight procedures. The annual performance goal is to assess and establish the strongest candidate technologies to meet the 10- decibel reduction in community noise.						X				X	X		X
2R4: NASA's research stresses operations systems for safe, efficient air traffic management and new aircraft configurations for high productivity utilization of existing runways. The annual performance goal is to demonstrate at least two decision support tools for arrival, surface, and departure operations, and define requirements for future aviation system concepts.		X						X			X		X

Aerospace Technology Enterprise FY2002		AEROSPACE FOCUSED						AEROSPACE BASE R&T					
	Budget Category	Aviation System Capacity	Aviation Safety Technology	Ultra-Efficient Engine Technology	Small Aircraft Transportation System	Quiet Aircraft Technology	2nd Generation RLV	Aero-Space Base R&T -- Computing, Information & Communication Technology	Aero-Space Base R&T -- Flight Research	Aero-Space Base R&T -- Propulsion & Power	Aero-Space Base R&T -- Vehicle System Technology	Aero-Space Base R&T -- Space Transfer & Launch Tech.	R&PM
Annual Performance Goal													
2R5: NASA's research stresses aircraft technologies which enable the use of existing small community and neighborhood airports, without requiring control towers, radar installations, and more land use for added runway protection zones. The annual performance goal is to baseline in partnership with the FAA the system engineering documents for the Small Aircraft Transportation System concept.					X						X		X
2R6: NASA’s investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews to support design and demonstration decisions.							X	X				X	X

Aerospace Technology Enterprise FY2002		AEROSPACE FOCUSED						AEROSPACE BASE R&T						
	Budget Category	Aviation System Capacity	Aviation Safety Technology	Ultra-Efficient Engine Technology	Small Aircraft Transportation System	Quiet Aircraft Technology	2nd Generation RLV	Aero-Space Base R&T -- Computing, Information & Communication Technology	Aero-Space Base R&T -- Flight Research	Aero-Space Base R&T -- Propulsion & Power	Aero-Space Base R&T -- Vehicle System Technology	Aero-Space Base R&T -- Space Transfer & Launch Tech.	R&PM
Annual Performance Goal													
2R7: NASA's investments emphasize thorough mission needs development, requirements definition, and risk reduction effort leading to commercially owned and operated launch systems to meet NASA needs with commercial application where possible. The annual performance goal is to complete risk reduction and architecture reviews and initial hardware demonstrations to support design and demonstration decisions.							X	X		X	X	X	X
2R8: NASA's long term research emphasizes innovative propulsion systems. The performance target is to conduct at least one electric propulsion test										X		X	
2R9: NASA's investments emphasize advances in experimental vehicles, flight testbeds, and computing tools to enable revolutionary designs. The annual performance goal is to conduct at least five demonstrations of revolutionary aerospace subsystems.								X	X	X	X	X	X

Aerospace Technology Enterprise FY2002		AEROSPACE FOCUSED						AEROSPACE BASE R&T					
	Budget Category	Aviation System Capacity	Aviation Safety Technology	Ultra-Efficient Engine Technology	Small Aircraft Transportation System	Quiet Aircraft Technology	2nd Generation RLV	Aero-Space Base R&T -- Computing, Information & Communication Technology	Aero-Space Base R&T -- Flight Research	Aero-Space Base R&T -- Propulsion & Power	Aero-Space Base R&T -- Vehicle System Technology	Aero-Space Base R&T -- Space Transfer & Launch Tech.	R&PM
Annual Performance Goal													
2R10: NASA's investments emphasize revolutionary technologies such as nanotechnology, information technology and biotechnology which could enable new missions and capabilities. The annual performance goal is to develop at least two new materials concepts and demonstrate the feasibility of at least two nanotechnology and two other concepts.								X		X	X	X	X
2R11: Continue the solicitation of customer feedback on the services, facilities, and expertise provided by the Aerospace Technology Enterprise.													X
2R12: Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 2002.													X
2R13: Review results of NASA and commercial-sector performed launch system architecture studies, related requirements, and refinements in planned risk-reduction investments.							X						X

Biological and Physical Research Enterprise (BPRE)

Mission

NASA's Office of Biological and Physical Research (OBPR) conducts interdisciplinary fundamental and applied research to pursue answers to the basic questions underlying human space flight:

- How can human existence expand beyond the home planet to achieve maximum benefits from space?
- How do fundamental laws of nature shape the evolution of life?

The microgravity environment of space allows scientists to open a new window on the most basic and important biological, chemical, and physical processes. At the same time, the space environment poses major challenges to the well-being of space travelers. Space flight exposes humans to low gravity and radiation environments never before encountered in our evolutionary history. As we seek to exploit the rich opportunities of space flight for fundamental research and commercial development, we must develop efficient and effective technologies and methods for protecting human health in space.

Goal 1: Conduct research to enable safe and productive human habitation of space.

OBPR conducts fundamental and applied research in the biological and physical sciences to reduce the health risks of space travel. We conduct research on technology for efficient, self-sustaining life-support systems to provide safe, hospitable environments for space exploration, and develop advanced technologies for healthcare delivery. Advances in healthcare first developed for the space flight environment are applied on Earth to enhance healthcare.

Goal 2: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

The space environment offers a unique laboratory in which to study biological and physical processes. Researchers take advantage of this environment to conduct experiments that are impossible on Earth. For example, most combustion processes on Earth are dominated by the fact that hot gases rise. In space, this is not the case, and hidden properties of combustion emerge. Materials scientists study the role of gravity in important industrial processes. Physicists take advantage of microgravity to study exotic forms of matter that are better handled in space. Biological researchers investigate the role of gravity in life processes and how the space environment affects living organisms. The knowledge derived from OBPR's diverse research will inform and expand scientific understanding, support economic and technological progress, and help to enable human exploration of space.

Goal 3: Enable and promote commercial research in space.

OBPR provides knowledge, policies, and technical support to facilitate industry investment in space research. OBPR will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector will grow to become the premier mechanism for applying space knowledge to benefit the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies.

Goal 4: Use space research opportunities to improve academic achievement and the quality of life.

OBPR seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond. We deliver value to the American people by facilitating access to the experience and excitement of space research. OBPR strives to involve society as a whole in the transformations that will be brought about by research in space.

Resource Requirements

(NOA, dollars in millions)

	FY1999	FY 2000	FY 2001	FY 2002
$M	$263.5	$274.7	$312.9	$360.9
CS FTE	420	382	372	484

With the formation of a new Biological and Physical Research Enterprise, resource requirements for annual performance goals are somewhat more transparent. Each annual performance goal is associated with a specific program budget; however, the majority of OBPR performance goals are overarching and interdependent in nature. They are not budgeted as discrete elements of OBPR programs.

Implementation Strategy

OBPR's program is implemented at seven NASA Field Centers and the Jet Propulsion Laboratory, as well as through the participation of Commercial Space Centers (CSCs), a National Space Biomedical Research Institute, and a National Center for Microgravity Research on Fluids and Combustion. OBPR relies upon an extensive external community of academic, commercial and government scientists and engineers for the implementation of its programs. OBPR-supported science and technology research projects are reviewed by scientific or technical peers. In selecting investigations and projects to support—and ultimately for access to space—OBPR follows peer-review processes appropriately designed for scientific research, technology research and development, and commercial research. Our peer review processes ensure the competitiveness and quality of OBPR research.

OBPR implements its research programs through ground-based as well as flight research. Ground-based research precedes flight research and employs NASA facilities such as drop towers, centrifuges, and bed-rest facilities. The flight research programs use the full spectrum of platforms, including free-flying satellites, Space Shuttle, and now ISS.

Roadmap: [Source: NASA Strategic Plan]

Near–term Plans (2000-2005)	Mid-term Plans (2006-2011)	Long-term Plans (2012-2025)
• Identify mechanisms of health risk and potential physiological and psychological problems to humans living and working in space, and begin developing and testing countermeasures. • Conduct scientific and engineering research and enable commercial research activities on the ISS to enrich health, safety, and the quality of life on Earth. • Begin developing interdisciplinary knowledge (e.g., biology, physics, materials) to support safe, effective, and affordable human/robotic exploration.	• Understand the effects of long-duration space flight (e.g., radiation), validate countermeasures and technology and begin developing countermeasures for long-duration space flight. • Extend our understanding of chemical, biological, and physical systems. • Test and validate technologies that can reduce the overall mass of human support systems by a factor of three (compared to 1990's levels).	• Apply and refine countermeasures for safe, effective, and affordable long-duration human space flight. • Achieve a deep understanding of the role of gravity in complex chemical, biological, and physical processes. • Test and validate technologies for safe, self-sufficient, and self-sustaining life support systems that can enable humans to live and work in space and on other planets for extended periods.

OBPR is preparing for the transition to a new era in human space flight. The International Space Station (ISS) will provide a growing capability as a research platform. OBPR will work to extract the maximum scientific and commercial return from this promising research facility while conducting research to ensure the health and safety of space travelers in the near term and into the future.

Performance Measures

OBPR will conduct interim evaluations and monitoring of performance targets at midyear and at the end of the fiscal year. OBPR will present progress on each annual performance goal to its NASA Advisory Committee subcommittee, the Biological and Physical Research Advisory Committee. This committee will evaluate progress toward each annual performance goal and assign a qualitative score of red, yellow, green, or blue, with blue indicating outstanding progress, green indicating satisfactory progress, yellow indicating poor or partially satisfactory progress, and red indicating unsatisfactory progress.

Goal: Conduct research to enable safe and productive human habitation of space.

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

Millions of years of evolution have molded the human body to cope with and rely upon gravity. Virtually every system of the body responds when a person travels to space. Weight-bearing bones lose about 1% of bone mass per month. Muscles atrophy, and nerves in the balance system begin to rewire their connections to take account of the sudden disappearance of up and down. Many of these changes pose significant health issues, especially when space travelers return to gravity. NASA research will identify methods that will efficiently control the effects of space travel and ensure the health and safety of future space travelers.

Public Benefit: The primary goal of this research is to improve health and safety for space travelers; however, this research also has the potential to make significant contributions to medical care on Earth. For example, space flight can provide models for exploring osteoporosis and other diseases of muscle and bone. It has provided unique insights into nerve regeneration and the capacity of the nervous system to grow, change, and adapt in response to environmental stimuli. The parallels between aging and space travel are currently under study by researchers at NASA and the National Institutes of Aging. OBPR has used the Critical Path Roadmap to link indicators under this Performance Goal to the Agency's longer-term objectives in this area of research.

Annual Performance Goal 2B1: Earn external review rating of “green” or “blue” by making progress in the following research focus areas as described in the associated indicators:

- Identify and test biomedical countermeasures that will make space flight safer for humans.
- Identify and test technologies that will enhance human performance in space flight.

Performance Indicators:

- Complete protocols for flight testing countermeasure to reduce kidney stone risk.
- Develop an investigation of crew nutritional needs and metabolism status.
- Prepare in-flight validation of cardiovascular countermeasures.
- Evaluate and provide annual report of the progress in reducing medical risk factors.

Public Benefit: Humans can only travel to space by bringing a microcosm of the Earth with us. We need an atmosphere, food, water, and protection from temperature extremes and space radiation. NASA research will develop advanced technologies for efficient life support systems to provide these needs with minimal resupply from Earth. These technologies will reduce the cost of space travel and may find application in process control systems for industry, and even in helping to provide clean environments in homes, vehicles, and offices.

Annual Performance Goal 2B2: Earn external review rating of “green” or “blue” by making progress in the following research focus area:

- Identify and test new technologies to improve life support systems for spacecraft.

Performance Indicators:

- OBPR will demonstrate, through vigorous research and technology development, a 33% reduction in the projected mass of a life support flight system compared to the current (FY 2001) system baselined for ISS. The quantitative calculation of this metric will be posted on the Internet.
- Complete a radiation protection plan that will guide future research and development to improve health and safety for space travelers.

Objective: Conduct research on biological and physical processes to enable future missions of exploration.

Basic research in the biological and physical sciences is an essential precursor to future advanced technologies and systems for supporting a human presence in space. Beyond reducing the cost and increasing safety for space travelers, this basic research promises to push the frontiers of knowledge and technology for Earth applications.

Public Benefit: Our collaborative effort with the National Cancer Institute will support the future development of next-generation instruments for molecular-level diagnostics for space and Earth application. Basic insights into biological and physical mechanisms behind physiological changes in space will support the future of human presence in space while adding to the store of biomedical knowledge that underlies medical care on Earth.

Annual Performance Goal 2B3: Earn external review rating of "green" or "blue" by making progress in the following research focus areas:

- Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring.
- Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers.

Performance Indicators:

- Collaborate with the National Cancer Institute to create and maintain a core program using academic, industrial, and government researchers to develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical processes.
- Develop a study on the effects of space flight on bone loss as a function of age in an animal model.
- Develop studies on space-flight-induced genomics changes.

Goal: Use the space environment as a laboratory to test the fundamental principles of physics, chemistry, and biology.

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

Gravity's influence is everywhere. From the structure that gives steel its strength, to the structure of bone in a growing child, gravity plays a role. Researchers can only eliminate the effects of gravity in space. In space, we can study how gravity has shaped life on Earth and how living things respond to its absence. In space, we enter a new realm of research in physics, chemistry, and biology. NASA conducts research in focused areas with the potential to improve life on Earth. We rely on the advice of the Space Studies Board of the National Research Council, as well as the NASA Advisory Committees and associated cross-disciplinary task groups to set the strategic direction of the program.

Public Benefit: Research on complex physical and biological systems has the potential to benefit industrial applications in optical computing and communications, pharmaceutical packaging, food manufacturing, cosmetics, and polymer manufacturing.

Annual Performance Goal 2B4: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators:

- Advance the scientific understanding of complex biological and physical systems.

Performance Indicators:

- Prepare an ISS research investigation on colloidal physics.
- Maintain a peer-reviewed research program in Complex Systems physics and chemistry.

Public Benefit: This biotechnology research may have applications in structural biology, rational drug design, and artificial tissues engineering for medical applications.

Annual Performance Goal 2B5: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators:

- Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.

Performance Indicators:

- Maintain a peer-reviewed research program in macromolecular and cellular biotechnology.
- Prepare ISS research investigations in protein crystallization and three-dimensional tissue culture.

Public Benefit: Space flight provides a unique environment for fundamental research in fluid physics and materials science which supports human space flight and produces valuable insights into industrial processes on Earth. Integrating fluid physics and materials science with fundamental biology provides unique new research capabilities that will be implemented by an interdisciplinary program with access to space.

Annual Performance Goal 2B6: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators:

- Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology.

Performance Indicators:

- Initiate the definition of a Bio-science and Engineering institute to drive novel concepts for space-based investigations in biomolecular systems.

Public Benefit: This basic research has the potential to substantially enhance the accuracy of our time-keeping standard, support development of ultra-precise Global Positioning System time measurements, and support the development of molecular-based medical diagnostic devices.

Annual Performance Goal 2B7: Earn external review rating of "green" or "blue" by making progress in the following research focus area:

- Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.

Performance Indicators:

- Maintain an outstanding and peer-reviewed research program in condensed matter physics, Bose-Einstein Condensation, and atomic clocks development for space-based utilization.
- Produce scientific discoveries in atomic and condensed matter physics, and publish in mainstream peer-reviewed archival journals.
- Design and develop flight experiment apparatus for low-temperature physics, laser cooling, and atomic physics investigations on the ISS.

Public Benefit: This research has the potential to support advances in energy production efficiency, combustion products emission control, advanced materials manufacturing, and the chemical engineering industry.

Annual Performance Goal 2B8: Earn external review rating of "green" or "blue" by making progress in the following research focus area:

- Investigate fundamental and unresolved issues in fluid physics, and materials and combustion science using gravity as a theoretical and experimental revealing tool.

Performance Indicators:

- Maintain an outstanding and peer-reviewed program in fluid physics, and materials and combustion sciences.
- Complete the preparation for ISS investigations in fundamental materials science to be carried out in the Microgravity Science Glovebox.
- Prepare two major space-based combustion research experiments for flight on the Space Shuttle.
- Initiate a new annual process to solicit and select peer-reviewed, ground-based investigations in materials science, fluid physics, and combustion research.

Public Benefit: This basic research has the potential to support improved medical care and agricultural performance by strengthening our basic understanding of biological processes.

Annual Performance Goal 2B9: Earn external review rating of “green” or “blue” by making progress in the following research focus area:

- Understand the role of gravity in biological processes at all levels of biological complexity.

Performance Indicators:

- Maintain an outstanding and peer-reviewed program in fundamental space biology.
- Develop and implement Fundamental Space Biology research plans to utilize early ISS capability.
- Determine baseline data requirements for model specimens to be used on ISS.
- Plan for incorporation of baseline data collection in ISS hardware validation flights.

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

Space flight opportunities for biological and physical research are very scarce. OBPR develops strategies and approaches to enhance flight opportunities and to support a balanced research program so as to maximize scientific return.

Public Benefit: By working with the scientific community, OBPR seeks to maximize scientific return from space flight opportunities.

Annual Performance Goal 2B10: In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.

Performance Indicators:

- Assume management responsibility for the ISS research budget.
- Begin procurement activities leading to a Non-Governmental Organization for Space Station Research.
- Coordinate scientific community participation in the definition of ISS research.
- Balance resource allocations and flight opportunities through a Partner Utilization Plan.
- Prepare peer-reviewed and commercial research investigations for execution on STS-107.

- Conduct early research on the International Space Station.

Goal: Enable and promote commercial research in space.

Objective: Provide technical support for companies to begin space research.
Objective: Foster commercial research endeavors with the International Space Station and other assets.

Ultimately, the solutions to the challenges of human space flight will open up new avenues of commerce. Even now, dozens of commercial firms conduct small-scale research projects in space. OBPR provides knowledge, policies, and technical support to facilitate industry investment in space research. OBPR will continue to enable commercial researchers to take advantage of space flight opportunities for proprietary research. The commercial sector will grow to become the premier mechanism for applying space knowledge to benefit the American people. Commercial applications of space knowledge will generate new products, new jobs, and new spin-off companies.

Public Benefit: The benefits of commercial research in space include improved products and services to enhance economic performance on Earth. In the long-term, economic activity in space will provide strengthened infrastructure for the exploration and development of space.

Annual Performance Goal 2B11: Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.

Performance Indicators:
- Maintain or increase non-NASA investment in commercial space research during the FY 2002 transition from a Shuttle-based to an ISS-based program.
- Maintain a ratio of non-NASA funding to NASA funding of not less than 3:1 in FY 2002.
- Ensure that one of the 39 product lines currently under investigation is brought to market, available for commercial purchase, in FY 2002.
- Enable at least 10 new, active industrial partnerships to be established with the Space Product Development Commercial Space Centers.

Objective: Systematically provide basic research knowledge to industry.

Public Benefit: Conducting outreach to the commercial community extends the benefits of commercial research to the broadest set of participants and strengthens the contributions of commercial research for the development of space.

Annual Performance Goal 2B12: Highlight ISS-based commercial space research at business meetings and conferences.

Performance Indicators:
- Support at least 3 business/trade conferences to highlight ISS-based commercial space research.

Goal: Use space research opportunities to improve academic achievement and the quality of life.

Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

Public Benefit: OBPR seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond.

Annual Performance Goal 2B13: Provide information and educational materials to American teachers.

Performance Indicators:

- Develop electronic and printed educational materials which focus on biological and physical research, and distribute these materials at at least three conferences and through the Internet.

Objective: Engage and involve the public in research in space.

Public Benefit: OBPR delivers value to the American people by facilitating access to the experience and excitement of space research. OBPR strives to involve society as a whole in the transformations that will be brought about by research in space.

Annual Performance Goal 2B14: Work with media outlets and public institutions to disseminate OBPR information to wide audiences.

Performance Indicators:

- Work with PBS and Discovery Channel producers to explore opportunities for TV products with space/research/microgravity themes.
- Work with Life Science Museum Network members to explore opportunities for the development of projects, special events, or workshops focused on Life Sciences biology-related research themes to attract and engage public audiences.
- Make available to wide audiences an online database of Commercial Space Center activities, including publications listings, patents, and other information useful to the public.

Verification/Validation

OBPR cooperates with NASA's Inspector General during an annual review of the accuracy of our reporting process. The Life and Microgravity Sciences and Applications Advisory Subcommittee is not expected to independently confirm the accuracy of data presented by OBPR. Rather, the Committee's role is to assess progress based on the data that OBPR presents and apply its expert judgement to produce an evaluation. The Office of the Inspector General selects a subset of targets for detailed audits to determine the accuracy and reliability of OBPR's data on performance targets.

Annual performance goals 2B1 through 2B9 are fundamentally qualitative in nature and the committee will have broad discretion in assigning scores on these goals based on performance indicators as well as other information. Annual performance goal 2B2 is evaluated using a novel formula developed by OBPR's Advanced Human Support Technology program. Details of this process are available for review on the program's website at http://ADVLIFESUPPORT.JSC.NASA.GOV/ under the title "Advanced Life Support Metric Document".

Annual Performance Goals 2B10 through 2B14 are more readily evaluated using objective criteria as established in their associated indicators.

MULTI-YEAR PERFORMANCE TREND
Biological and Physical Research Enterprise (BPRE)

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H29: Perform component and subsystem ground tests without humans in the loop to demonstrate advanced technologies, including biological water processor, and flight test a new electronic "nose" sensor on a chip.	0H31: Complete the first phase (including outfitting three test chambers) of the Advanced Life Support System Integration Test Bed facility that will provide the capability to conduct a series of long duration, human-in-the-loop, advanced technology tests over the next six years. Demonstrate key technology capabilities for human support, such as advanced techniques for water processing using microbes, waste processing using biological degradation and fluidized bed incineration, a no-expendable trace gas contaminant control system, solid waste processing, and flight test of a miniature mass spectrometer.	1H18 Demonstrate, in ground test, at least one technology that could reduce up to 25% of life support logistics over ISS baseline and release report of progress for review on the Internet.	2B2 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Identify and test new technologies to improve life support systems for spacecraft.
Assessment	Green	Green	TBD	TBD

Objective: Conduct research to ensure the health, safety, and performance of humans living and working in space.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H25 Complete the development of countermeasure research protocols, and begin testing a minimum of three countermeasures intended to protect bone, muscle, and physical work capacity. H6 Publish a report defining the time course adaptations in the balance system to altered gravitational environments. H10 Document Mir radiation research data to facilitate ISS EVA planning. H7 Document Mir data lessons learned to facilitate ISS biomedical and countermeasure research.	0H26 Develop medical protocols and test the capability of the Crew Health Care System as integrated in the ISS U.S. Laboratory. 0H25 Evaluate and develop for flight testing a minimum of three major research protocols intended to protect bone, muscle, and physical work capacity and prepare a minimum of 10 biomedical research experiments, (utilizing the capabilities of the STS and ISS HRF) to study human responses to the gravitational environment.	1H17 Develop new biomedical and technological capabilities to facilitate living and working in space and safe return to Earth. 1H31 Initiate implementation of the Bioastronautics Initiative by beginning a NASA /NCI collaboration and conducting a peer review of NSBRI to assess expansion.	2B1 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Identify and test biomedical countermeasures that will make space flight safer for humans. • Identify and test technologies that will enhance human performance in space flight.
Assessment	Green	Green	TBD	TBD

Objective: Conduct research on biological and physical processes to enable future missions of exploration..

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H5 Publish a report of comparison of 3 different biological models to understand the influence of gravity on the nervous system. H8 Document Mir data lessons learned to facilitate ISS research in fundamental biology and regenerative life support.	0H33 Complete Radiation Research Instrument for Mars 2001 mission to study transit, orbital, and surface radiation effects and conduct three workshops to define and prioritize research tasks in subjects such as radiation shielding materials, in situ resource utilization, and fluids management and heat transfer technology. Complete the science definition of granular flows, flight, and dust management experiments to begin gathering research data to alleviate critical problems of dust buildup, habitat foundation engineering, and rover performance during planetary exploration.	1H31 Initiate implementation of the Bioastronautics Initiative by beginning a NASA /NCI collaboration and conducting a peer review of NSBRI to assess expansion.	2B3 Earn external review rating of "green" or "blue" by making progress in the following research focus areas: • Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring. • Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers.
Assessment	Green	Green	TBD	TBD
APG	H26 Initiate a collaborative program to design and develop instruments		1H1 Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 missions.	
Assessment	Green		TBD	

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
APG				2B4 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Advance the scientific understanding of complex biological and physical systems.
Assessment				TBD
APG	H9 Analyze Mir data to achieve a 3-year jump-start for cell culture and protein crystal growth research and document analyses & lessons learned.			2B5 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.
Assessment	Green			TBD

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG				2B6 Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: • Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology.
Assessment				TBD
APG				2B7 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.
Assessment				TBD

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H13 Use data obtained by fluid physics experiments on suspensions of colloidal particles on MSL-1 to answer fundamental questions in condensed matter physics regarding the transition between liquid and solid phases and publish data on the transition from liquids to solids and the results in peer-reviewed open literature. H11 Improve predictive capabilities of soot processes by at least 50% through analysis of MSL-1 data; publish results in peer-reviewed open literature. H12 Use MSL-1 results to eliminate one of the three primary fluid flow regimes from consideration by casting engineers, and publish this result in peer reviewed literature. Casting engineers may use this information to improve metal casting processes in industry.	0H11 Using suborbital rockets, complete one combustion experiment on the flame spread of liquid fuels to better control Earth/space-based fire hazards, and conduct one investigation to test theories of fundamental physics properties and physical laws of fluids to provide key data for earth and space-based processing materials; report the results.		2B8 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Investigate fundamental and unresolved issues in fluid physics, and materials and combustion sciences using gravity as a theoretical and experimental revealing tool.
Assessment	Green	Red		TBD

Objective: Investigate chemical, biological, and physical processes in the space environment, in partnership with the scientific community.

	FY 1999	FY 2000	FY 2001	FY 2002
APG				2B9 Earn external review rating of "green" or "blue" by making progress in the following research focus area: • Understand the role of gravity in biological processes at all levels of biological complexity.
Assessment				TBD

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

APG				2B10 In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.
Assessment				TBD
APG		0H26 Develop medical protocols and test the capability of the Crew Health Care System as integrated in the ISS U.S. Laboratory.	1H5 Continue initial research on the International Space Station by conducting 6 to 10 investigations.	
Assessment		Green	TBD	

Objective: Develop strategies to maximize scientific research output on the International Space Station and other space research platforms.

	FY 1999	FY 2000	FY 2001	FY 2002
APG		0H9 Complete data reduction from the STS-95 Research Module mission. Begin to explore new cooperative efforts with NIH in the area of aging and transfer space-derived research for industry development of a new drug to treat Chagas' disease.	1H4 Conduct outstanding peer-reviewed and commercial research on STS-107 to advance knowledge in the fields of medicine, fundamental biology, biotechnology, fluid physics, materials processing and combustion	
Assessment		Green	TBD	
APG	H1 Support an expanded research program of approximately 800 investigations, an increase of ~9% over FY 1998. H2 Publish 90% of FY 1998 science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make it available on the Internet. H3 Establish a National Center for Evolutionary Biology with participation of at least 5 research institutions and engaging at least 20 investigators.	0H1 Support an expanded research program of approximately 935 investigations, an increase of ~17% over FY 1999. Publish 100 percent of science research progress in the annual OLMSA Life Sciences and Microgravity Research Program Task Bibliographies and make this available on the Internet.	1H3 Support an expanded, productive research community to include 975 investigations annually by 2001.	
Assessment	Green	Green	TBD	

Objective: Foster commercial research endeavors with the International Space Station and other assets.
Objective: Provide technical support for companies to begin space research.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H35 Increase non-NASA investment (cash and in-kind) in space research from $35M in FY96 to at least $50M in FY 1999, a 40% increase. H30 Complete the development of a commercialization plan for the ISS and Space Shuttle in partnership with the research and commercial investment communities and define and recommend policy and legislative changes. H36 Establish a new food technology Commercial Space Center.	0H47 Establish up to 2 new Commercial Space Centers. 0H49 Foster the establishment of a telemedicine hub in Western Europe. NASA and CNES will develop an international telemedicine program to incorporate and connect existing medical informatics capabilities into a user-friendly commercial electronic telemedicine hub and apply lessons learned to human space flight. 0H46 Utilize at least 30% of Space Shuttle and ISS FY 2000 capabilities for commercial investigations, per the U.S. Partner Utilization Plan.	1H23 Foster commercial endeavors by reviewing and/or implementing new policies and plans such as the Space Station resource pricing policy and intellectual property rights policy. Ensure that Space Station resources allocated to commercial research are utilized by commercial partners to develop commercial products and improve industrial processes. 1H22 Establish at least ten new, active industrial partnerships to research tomorrow's space products and improve industrial processes through NASA's Commercial Space Centers, and find opportunities for space experiments.	2B11 Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.
Assessment	Green (H35, H36); Yellow (H30)	Green	TBD	TBD

Objective: Systematically provide basic research knowledge to industry.

APG				2B12 Highlight ISS-based commercial space research at business meetings and conferences.
Assessment				TBD

Objective: Advance the scientific, technological, and academic achievement of the Nation by sharing our knowledge, capabilities, and assets.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H37 Initiate a curriculum development program, in partnership with the International Technology Education Association (ITEA), for gravity related educational modules for national distribution which meet the current National Science Teachers Association (NSTA) National Standards for Science for Grades K-12, and the ITEA National Standards for Technology Education to be published June 1999. H39 Conduct at least two demonstrations of the applicability of the "Telemedicine Instrumentation Pack" for health care delivery to remote areas. H40 Demonstrate the application of laser light scattering technology for early detection of eye-tissue damage from Diabetes; publish results in peer-reviewed open literature.	0H56 The NASA-Sponsored National Space Biomedical Research Institute will conduct an open symposium relaying the results of space-oriented research activities focusing on up to 10 ground-related applications with the participation of interested investigators; publish results in a conference proceedings report.	1H26 Support participation in HEDS research.	2B13 Provide information and educational materials to American teachers.
Assessment	Green	Green	TBD	TBD

Objective: Engage and involve the public in research in space.

	FY 1999	FY 2000	FY 2001	FY 2002
APG	H38 Expand the microgravity research program's World Wide Web-based digital image archive established in 1998 by 50%.			2B14 Work with media outlets and public institutions to disseminate OBPR information to wide audiences.
Assessment	Green			TBD

Biological and Physical Research Enterprise FY 2002	Advanced Human Support Technology	Biomedical Research & Countermeasures	Fundamental Space Biology	Physical Sciences Research	Space Product Development	Mission Integration	Health Research
2B1: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Identify and test biomedical countermeasures that will make space flight safer for humans. Identify and test technologies that will enhance human performance in space flight.		X					
2B2: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Identify and test new technologies to improve life support systems for spacecraft.	X						
2B3: Earn external review rating of "green" or "blue" by making progress in the following research focus areas: Develop and test cutting-edge methods and instruments to support molecular-level diagnostics for physiological and chemical process monitoring. Identify and study changes in biological and physical mechanisms that might be exploited for ultimate application to improving the health and safety of space travelers.			X	X			
2B4: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Advance the scientific understanding of complex biological and physical systems.				X			
2B5: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Elucidate the detailed physical and chemical processes associated with macromolecular crystal growth and cellular assembling processes in tissue cultures.				X			
2B6: Earn external review rating of "green" or "blue" by making progress in the following research focus areas as described in the associated indicators: Initiate a focused research program specifically integrating fluid physics and materials science with fundamental biology.				X			

Biological and Physical Research Enterprise FY 2002	Advanced Human Support Technology	Biomedical Research & Countermeasures	Fundamental Space Biology	Physical Sciences Research	Space Product Development	Mission Integration	Health Research
2B7: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Investigate fundamental and unresolved issues in condensed matter physics and atomic physics, and carry out atomic clock development for space-based utilization.				X			
2B8: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Investigate fundamental and unresolved issues in fluid physics, and materials and combustion sciences using gravity as a theoretical and experimental revealing tool.				X			
2B9: Earn external review rating of "green" or "blue" by making progress in the following research focus area: Understand the role of gravity in biological processes at all levels of biological complexity.			X				
2B10: In close coordination with the research community, allocate flight resources to achieve a balanced and productive research program.	X	X	X	X	X	X	
2B11: Engage the commercial community and encourage non-NASA investment in commercial space research by meeting at least three of four performance indicators.					X		
2B12: Highlight ISS-based commercial space research at business meetings and conferences.					X		
2B13: Provide information and educational materials to American teachers.	X	X	X	X	X	X	
2B14: Work with media outlets and public institutions to disseminate OBPR information to wide audiences .	X	X	X	X	X	X	

Manage Strategically Crosscutting Process

Mission

Through NASA, the American people have invested in America's future by supporting an irreplaceable public aerospace research and development infrastructure consisting of a unique combination of physical resources and human talents. Managing these resources effectively and strategically is critical to achieving NASA's goals and objectives. Therefore, the goal of the Manage Strategically cross-cutting process is to provide a basis for the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices. By integrating good general management practices with NASA's strategic processes, the Agency ensures that decisions are consistent with the goals, objectives, and strategies contained in NASA's Strategic, Implementation, and Performance Plans. Managing strategically also encourages all parts of the Agency to proceed together toward achieving a single set of strategic goals while enhancing management's ability to leverage limited resources, standardize processes where it makes sense to do so, streamline processes for timely results, and ensure rapid, reliable, open exchanges of information. Finally, managing strategically ensures that the public's investment in NASA is well-served and that the Agency's initiatives and achievements continuously inspire and serve America and benefit the quality of life on Earth for all humankind.

Implementation Strategy

For FY 2002, NASA's strategic management performance objectives (and associated annual performance goals) require the Agency to make the most effective use of appropriated funds, workforce, facilities, procurement processes and information technologies. In all cases, the performance metrics selected for FY 2002 reflect key management challenges particularly facing NASA. Additionally, several of the management areas, including management of human capital and financial management, address issues that have been identified by other organizations, including the General Accounting Office, as being Government-wide major management challenges. Finally, these management areas are also consistent with the Administration's reform agenda, which emphasize a Federal Government that is citizen-centered, results-oriented, and market-based.

Performance Metrics

Goal: Enable the Agency to carry out its responsibilities effectively, efficiently, and safely through sound management decisions and practices.

In order to know how successful we are in meeting the Manage Strategically goals and objectives, we have established nine annual performance goals, with accompanying indicators, against which we will measure our progress.

Objective: Protect the safety of our people and facilities and the health of our workforce.

Public Benefit: NASA protects the public's investment in our vision and missions by protecting the safety of the general public, the NASA astronauts and pilots, the NASA workforce, and our high-value equipment and property on and off the ground. The Agency's passion for and commitment to safety permeate everything we do, and all performance goals and indicators reflect NASA's priority-one commitment to health and safety, especially the goals and performance indicators in support of this managing strategically performance objective.

Annual Performance Goal: NASA will increase the safety of its infrastructure and the health of its workforce through facilities safety improvements, reduced environmental hazards, increased physical security, enhanced safety and health awareness, and appropriate tools and procedures for health enhancement. (2MS1)

- No fatalities will result from NASA mishaps.
- Per the Federal Worker 2000 Initiative, reduce the overall occurrence of injuries (due to occupational injury or illness) by 3% per year from the FY 1997 baseline to 1.15 occurrences per 100 workers.
- Award construction contract(s) for all identified critical facilities safety requirements as specified in the Agency Annual Construction Program.
- Award/modify all planned contracts for physical security upgrades to NASA's minimum essential infrastructure defined in the NASA Critical Infrastructure Plan.
- Reduce the level of Agency environmental noncompliance incidents and releases in order to achieve a 5% reduction from the FY 2000 level by 2005.
- Standardize and implement minimum elements of employee preventive and medical monitoring examinations to standardize services across the Agency using the recommendations from the U.S. Preventive Health Services Task Force.
- Establish a mechanism to aggregate employee epidemiological preventive health risk data for long-term tracking and as a basis for policy (This action will begin the process of creating an employee longitudinal health study similar to the Astronaut Longitudinal Health Study by establishing a voluntary, statistically significant pool of employees at each Center. This pool could potentially expand the control group for the Astronaut Study and will give NASA insight into any health hazards peculiar to each Center.).
- Develop and implement a medical quality assurance system based on comprehensive program audits of all aspects of health care delivery and assurances of professional competency.

This is NASA's first performance plan in which the inextricable relationship between safety and health has been clearly highlighted. The metrics contained under this annual performance goal focus on all components of ensuring a physically and psychologically safe and healthy work environment - by preventing worker and workplace mishaps.

Consistent with the Agency's Safety Initiative (ASI), launched in February 1999, NASA identified safety as its number one core value. ASI is aimed at strengthening NASA capabilities so that safety permeates every aspect of our work and that we routinely incorporate safety and health principles and practices into daily decision making. As a key component of ASI, the Office of the Chief Health and Medical Officer, created in May 2000, provides strategic direction and oversight of all elements contributing to the achievement of a single goal – the protection of the health of the entire NASA workforce through optimal health care delivery and professional competency across the Agency. On the tactical level, this is accomplished by incorporating health and safety principles and practices into daily decision making at every level to ensure NASA adheres to the highest medical and ethical standards and satisfies all regulatory and statutory requirements.

Objective: Achieve the most productive application of Federal acquisition policies.

Public Benefit: NASA serves the public interest by implementing acquisition efficiencies and cost-saving strategies that provide the best return on the public's investment. These include streamlining acquisition regulations, assigning contractors more program-integration responsibility and accountability, and focusing NASA's civil service workforce on research and development activities rather than operational activities. In addition, NASA continuously seeks opportunities to partner with small, small disadvantaged, and women-owned businesses to increase the competitive base from which we purchase goods and services.

Annual Performance Goal: Continue to take advantage of opportunities for improved contract management by maintaining a high proportion of Performance Based Contracts (PBCs). (2MS2)

- Maintaining PBC obligations at greater than 80% of funds available for PBCs (funds available exclude grants, cooperative agreements, actions under $100,000, SBIR, STTR, FFRDCs, intra-governmental agreements, and contracts with foreign governments and organizations).

In order to utilize all categories of small business to the maximum extent practicable, at least meeting or exceeding the socioeconomic business goals set by Federal law or negotiated with the Small Business Administration, our annual performance goal will be:

Annual Performance Goal: Continue integrating small, small disadvantaged, and women-owned business together with minority universities into the competitive base from which NASA can purchase goods and services. (2MS9)

- Achieve at least an 8% Congressionally mandated goal for annual funding to small disadvantaged businesses (includes funding for prime and subcontractors awarded to programs supporting small disadvantaged businesses, Historically Black Colleges and Universities and other minority educational institutions, and women-owned small businesses).
- Award 1 percent of NASA's total contract and subcontract dollars to Historically Black Colleges and Universities and other minority institutions.

Addressing Procurement Management Challenges: NASA Office of Procurement has undertaken proactive management approaches in three key areas: human capital; outsourcing and oversight; and electronic commerce.

Human Capital: Over the last several years, procurement positions in the GS 1102 job series have been targeted areas for staff reductions. To help mitigate the impact of this decision on its customers and to ensure that the acquisition function remained viable at NASA, the Office of Procurement undertook several initiatives: 1) the NASA Career Development and Procurement Certification Programs, designed to ensure that acquisition professionals received uniform, high quality training that would meet or exceed statutory standards; 2) NASA's Contracting Intern Program, designed to ensure that an adequate number of well-trained, college-educated, entry level talent was available to the Agency to offset downsizing, retirements, and demographic trends (i.e., the aging of the work force); and 3) Rotational Assignments with Industry, designed to add a corporate experience dimension to the Office of Procurement's other developmental programs. The program seeks to equip already high performing, senior acquisition professionals with the tools necessary to help them assume future procurement management and other leadership. Collectively, the three programs address entry-level, mid-level, and senior-level staff developmental needs.

Outsourcing and Oversight: On November 2000, the Associate Administrator for Procurement and the Associate Administrator for Safety and Mission Assurance jointly announced the establishment of the Surveillance Planning Team. The overall goal of the team is to provide policy direction and procedural guidance on appropriate surveillance planning for NASA-contracted work based on the risk associated with the work and contractor involvement. Team membership includes representatives from the Office of Procurement, the Office of Safety and Mission Assurance, Enterprise Offices, and other Functional Offices. The Office of Procurement also continues to work with the Defense Contract Management Agency, the Defense Contract Audit Agency, and other service providers to ensure that each dollar NASA spends on delegated contract oversight functions returns the best value possible in support of Agency mission objectives.

Electronic Commerce: The Office of Procurement continues to focus on the Internet as a means to achieve rapid, low-cost, reliable delivery of procurement information to broad audiences, especially small and small disadvantaged business concerns. In a recent report (GAO/NSIAD-99-37 February 1999), GAO concluded that the NASA Acquisition Internet Service (NAIS), established as the mechanism to implement electronic commerce by the Office of Procurement, "is a simple, effective, and user-friendly system for disseminating information on contract opportunities." NAIS has won both government and private sector praise for its accomplishments. Since its inception in 1994, NAIS has evolved into a portal that provides a broad range of procurement-related functions and information.

Delivering on one of its key goals, NAIS has streamlined or eliminated many of the steps required by the paper-based process for publicizing synopses of contracting opportunities and issuing solicitations. Contractors have praised the system for allowing them to electronically track contracting opportunities at NASA or to track only certain types of opportunities that best match their core capabilities. Prior to NAIS, contractors would either scan the Commerce Business Daily, or periodically call or visit NASA's procurement offices to identify contracting opportunities. NAIS will continue to expand and refine its offerings as it pursues its objective of being the electronic backbone for the Office of Procurement's various electronic initiatives.

Addressing the Small Business Challenge: In the new century, the world of business is more diverse and more technologically driven. Business and their customers are much more diverse – women, individuals with disabilities, and minority-owned businesses are important players. The rapid pace of technological advances pose both opportunities and challenges for small business. Small businesses are at the forefront of technological change because they are flexible and close to the customer. Accordingly, NASA’s Office of Small and Disadvantaged Business Utilization will continue its effort to increase contract and subcontract dollars awarded to small disadvantaged businesses, particularly in high technology areas. This includes the participation of such firms in NASA’s technology transfer and commercialization activities.

For FY 2002, the NASA Administrator has, as part of the overall small disadvantaged business goal, established a specific Agency-wide goal for awards to Historically Black Colleges and Universities and other minority institutions of 1 percent of NASA's total contract and subcontract dollars to increase utilization of these entities. These entities currently receive about 0.5 percent of NASA's total procurement dollars. These new awards will be based upon conformance with NASA's mission needs, technical superiority, and costs reasonableness. It is NASA's expectation that the entire student population of these universities will benefit from these expanded opportunities to satisfy NASA's programmatic requirements.

Objective: Manage our fiscal and physical resources optimally.

Public Benefit: NASA's budget and physical assets represent a significant investment to the American taxpayers, so it is incumbent on the Agency to manage these resources effectively and efficiently to optimize the return to the public on their investment. Agency strategies for ensuring optimal return include partnering, value engineering, outsourcing, performance-based contracting, energy conservation, recycling, and pollution prevention.

Annual Performance Goal: Revitalize Agency facilities and reduce environmental liability. (2MS3)
- Improve facility revitalization rate to 100-year frequency for all facilities as identified by the integrated long-term Agency plan.
- Reduce the Agency's unfunded environmental liability through a long-term strategy, annually investing an amount of not less than 3-5% of the Agency's environmental liability in environmental compliance and restoration funding.

Annual Performance Goal: Improve the Agency's financial management and accountability. (2MS10)
- Cost at least 75% of the resources authority available to cost during the fiscal year.
- Initiate the pilot phase (pilot Center cut-over) of the Core Financial project and initiate at least one other module project.

<u>Addressing Financial Management Challenges</u>:

Integrated Financial Management System: During the fall of 2000, the IFM program was totally restructured. The contract with the incumbent system developer,was terminated. The critical need for new integrated financial management systems was reaffirmed by the Agency leadership and an extensive planning effort was initiated. The program concept was significantly modified based on successful benchmarks from both the commercial and federal sectors. Rather than pursue a large-scale implementation approach, individual projects for specific functions were created based on the availability of commercial software applications. A best of suite strategy was adopted where Core Financial system requirements would drive the selection of an Enterprise Resource Planning (ERP) application. The ability of that application to be extended to fill a number of the other IFM requirements, as well as past performance in successful implementations, were key selection criteria.

An Agency-level project team is in place at the Marshall Space Flight Center, the Lead Center for the project, and the design phase will begin in February 2002. In addition, three "pathfinder" projects have begun to test out the processes and technical requirements for Agency-wide implementation of new administrative systems. The Langley Research Center is leading implementation of a new Travel Management system, and the Goddard Space Flight Center is leading projects for Resume

Management and Position Description Management. All three of these projects will be complete before the Core Financial Project enters the implementation phase.

Obligations Management: The Office of the Chief Financial Officer has worked closely with the Office of Inspector General (OIG) to address the obligations management challenges compiled by the OIG in its December 1, 2000 report. The issue of matching Agency disbursements to obligations was resolved with the publication of a November 2000 revision to the Financial Management Manual (FMM) 9011-5, which provided further written clarification of NASA's existing practices in this area. Matters discussed in the OIG audit of internal controls over processing deobligations were resolved through the Langley Research Center and Marshall Space Flight Center review of the transactions in question (the review established that these transactions were valid), and through the October 24, 2000 publication of new guidance in FMM 9041-17 regarding the recording of deobligations and required supporting documentation. Finally, the error in the preparation of the 1999 Statement of Budgetary Resources was a Headquarters' reporting error which had no budgetary impact; it was not an indication "...that significant uncertainty exists regarding how to properly manage obligations."

Objective: Enhance the security, efficiency, and support provided by our information technology resources.

Public Benefit: The public's investment in NASA ensures that the Agency's explorers, pioneers, and innovators can continue to expand frontiers in air and space. But, NASA's missions to advance and communicate scientific knowledge and understanding of the Earth, the solar system, and the universe, to use and develop space, and to research, develop, verify, and transfer advanced aeronautics and space technologies require optimal efficiencies in the use of NASA's limited Information Technology (IT) resources. To achieve this goal, NASA's IT planning is focused on four areas: safety and security, cost-effective common infrastructure and services, innovative technology and practices, and emerging IT areas (e.g., e-Business and e-Government).

Annual Performance Goal: Improve IT infrastructure service delivery by providing increased capability and efficiency while maintaining a customer rating of satisfactory. (2MS4)

- Improve IT infrastructure service delivery to provide increased capability and efficiency while maintaining a customer rating of satisfactory and holding costs per resource unit to established baselines for each major IT service.

Service	Established Cost Baseline
NASA ADP Consolidation Center (NACC)	$3.5 M per Processing Resource Unit
NASA Integrated Services Network (NISN)	$0.78/ KBPS per month
Outsourcing Desktop Initiative for NASA (ODIN)	$2,940 per Standard Workstation

Annual Performance Goal: Enhance IT security by meeting established performance indicators in three critical areas: Vulnerabilities Detected; Training; and IT Security Plans. (2MS5)

- Reduce known system vulnerabilities across all NASA Centers to at least the established target ratios (10 percent of systems scanned).

- Provide IT security awareness training to NASA employees, managers, and system administrators at or above targeted levels (below).
- Complete 90 percent of ITS plans for critical systems, including authorization to process.

IT Security Element	FY 2002 Target
Percentage Vulnerabilities Detected to Systems Scanned	10%
ITS Awareness Training:	
Civil Service Employees	80%
Civil Service Managers	95%
Civil Service System Administrators	90%
IT Security Plans completed for critical systems	90%

Annual Performance Goal: Enhance mission success through seamless, community-focused electronic service delivery. (2MS6)
- Develop the eNASA Strategic Plan and Roadmap to deliver electronic services and information to the public, partners, suppliers, key stakeholders, and the internal employees and teams that execute NASA's missions.
- Make the NASA Web more accessible, community-focused, and useful to all of NASA's diverse audiences as demonstrated by increased customer satisfaction from the FY 01 baseline survey results.
- Increase the scope and level of corporate and shared electronic services from the FY01 baseline.
- Implement digital signatures that are accepted by Federal Agencies for secure online communications.
- Post a majority of the NASA grants announcements online by the end of FY02, consistent with interagency efforts such as the Federal Commons Initiative which seeks to automate the Federal grants process.

Addressing the IT Management Challenge: While IT Security remains a significant area of management concern, the Agency has made an extensive, concerted effort to improve IT security. This effort has been framed by several audits: a 1998 review by Agency staff; several Inspector General audits; and a 1999 report by the General Accounting Office. The evaluations concluded that significant improvements were needed to counteract the threat to critical systems. NASA responded vigorously to the recommendations during 1999 and the first half of 2000 with an aggressive program to remedy deficiencies as quickly as possible. The IT security objectives established include:
- Improving adherence to Agency IT security policy;
- Reducing system and application vulnerabilities;
- Improving intrusion monitoring, reporting, and response;
- Achieving a trained workforce of users, managers, system administrators, and network administrators; and
- Improving mechanisms for user authentication and data protection.

In FY 2000, NASA started a Vulnerability Reduction Program to identify and target a list of high-risk exploits and vulnerabilities and to take steps to reduce the vulnerability. NASA has installed a common set of network auditing tools to scan systems for a set of known vulnerabilities; the number of vulnerabilities per system has been reduced. In FY 2002, NASA will update the set of vulnerabilities to be scanned across the agency to reflect the evolving threat.

In FY 2000, NASA also installed a common set of intrusion monitoring tools to improve detection of attacks on systems and to make it easier to determine whether an attack experienced by one Center is also being conducted against other Centers. The success of the network monitoring is evidenced by a four-fold decrease in the ratio of successful attacks to attempted attacks in FY 2000.

Both the GAO audit and the internal IT security program review noted that the NASA IT security training practices were inadequate and inconsistent. To address these criticisms, NASA conducted IT security awareness training for employees and onsite contractors and specialized IT security training for managers. Since system and network administrators are the first line of defense in protecting NASA's IT assets from intrusions and detecting intrusions when they do occur, more specialized training for this group is planned for FY 2001 and 2002. The use of web-based training enables the Agency to broaden course offerings, simplify distribution, and make training available to any employee who has access to the Internet.

In FY 2000, NASA also began a concerted effort to update the IT security plans for critical systems, including signed authorization to process. In FY 2002 NASA will complete this effort for Special Management Attention Systems, Mission systems, and systems with Business and Restricted Technology data. While substantial progress has been made in closing out most of the IT-security recommendations, NASA will continue making IT security an integral part of all systems operated by the Agency. NASA acknowledges that significant improvements must be followed by a focused, ongoing effort.

Objective: Invest wisely in our use of human capital, developing and drawing upon the talents of all our people.

Public Benefit: NASA's human capital investment strategies are rooted in the Agency's belief that employees are our most important resource. Therefore, to deliver on our research and development commitments to the public, NASA manages this resource consistent with changing Agency goals and objectives. In addition, NASA is committed to attracting and retaining a workforce that is: (1) representative at all levels of the diverse public it serves; and (2) renowned for its world-class, cutting-edge skills and competencies. To ensure that we retain a skilled, creative, and effective human resources capability that meets taxpayer expectations, NASA is striving to anticipate future human capital planning challenges and workforce issues as the Agency moves away from operations and toward its primary mission of research, development, and scientific discovery.

Annual Performance Goal: Align management of human resources to best achieve Agency strategic goals and objectives. (2MS7)

- By September 30, 2002, develop, test, and evaluate at each NASA Center a prototype of a consistent, Agency-wide workforce planning and reporting system that incorporates the current FAIR Inventory process.
- Develop an initiative to enhance Centers' recruitment capabilities, focusing on fresh-outs.
- Maintain, on an Agency-wide basis (excluding the Inspector General), the supervisor to employee ratio of 1:10 within a range of $\pm$ .5.

Additionally, to emphasize recruitment and revitalization of a diverse NASA workforce, our annual performance goal is:

Annual Performance Goal: Attract and retain a workforce that is representative at all levels of America's diversity. (2MS8)

- During the fiscal year, increase representation of minorities by at least 0.6 percent, women by at least 0.4 percent, and individuals with targeted disabilities by at least .085 percent.

Addressing the Human Capital Management Challenge: Over the last several years, NASA has aggressively conducted a series of internal reviews designed to reduce the size of the NASA workforce while continuing to focus on safety and mission success. Between FY 1993 and FY 2000, the Agency experienced a 26 percent civil servant reduction (with the Headquarters reduced by more than 50 percent); achieved a 15 percent reduction in Senior Executive Service positions Agency-wide (exceeding the mandated 10 percent reduction); and increased, on an Agencywide basis (excluding the Inspector General), the supervisor to employee ratio from 1:6 to 1:10. During FY 2000, NASA renewed the Agency's focus on the restructure and revitalization of the NASA workforce.

NASA's human capital management strategy centers on:

- attracting and retaining a high caliber, high tech, and diverse workforce whose skills and competencies are aligned with Agency mission objectives;
- investing in the technical training and career development of this critical resource; and
- cultivating a continued pipeline of talent to meet future science, math, and technology needs.

In formulating its strategy, the Agency has considered findings and recommendations contained in both internal reviews and external reports touching on human capital issues, including those of the Aerospace Safety Advisory Panel, the Office of Management and Budget, and the General Accounting Office.

In FY 2001, the Agency began a strategic resource planning activity, based on Centers' future vision and mission and taking into account critical workforce capabilities and facilities needed. Building on that activity in FY 2002, the Agency will in develop a process by which Centers will implement consistent workforce planning. The result will be a plan for each Center that links staffing, funding resources, mission and activities, and core competencies. It will enable the Centers to focus on recruitment, retention, training, succession and career development tailored to their individual circumstances while supporting Agency goals and objectives. This effort, in concert with identifying tools and flexibilities to recruit and retain needed skills, will enable NASA to have the right people in the right place at the right time to ensure mission success and safety. A Management Advisory Committee also has been established to review NASA's organization structure. It will complete a study of ways to delayer management levels to streamline organizations and develop an implementation plan. The study will focus on deputy positions and explore other rebalancing measures.

The Agency initiated a strategy in FY 2000 to accomplish work through a balance of permanent civil servants, time-limited civil service appointees, and individuals from the academic world who contribute through post-doctoral fellowships, grants programs, Intergovernmental Personnel Act assignments, or other partnerships. The intent is to draw from a variety of sources to ensure the effective use of talent both within and outside the Agency. The use of non-permanent civil servants, where it makes sense, can be a means to infuse the NASA workforce with fresh ideas and allow the Agency to make changes quickly and efficiently with minimal adverse impact on the core workforce. Combined with support from contractors (approximately 85 percent of NASA's annual budget is contracted out), this approach will permit the Agency to focus on being a premier research and development organization – doing the things that NASA does best and relying on others to take on operations and other appropriate functions.

To counterbalance the aging of the workforce due to the halt in the influx of new college graduates during the years of downsizing, NASA intends in FY 2002 to develop an initiative to enhance Centers' recruitment capabilities, focusing on hiring fresh-outs. The Agency also continues to look for ways to help assure a future pipeline of talent from which NASA and others can draw. For example, FY 2001 marks the pilot year of the new NASA Undergraduate Student Research Program. This Agency-wide program was developed to extend and strengthen NASA's commitment to educational excellence and university research and to highlight the critical need to increase the Nation's undergraduate and graduate science, engineering, mathematics, and technology skill base. The Undergraduate Student Research Program also will build a national program bridge from existing NASA K-12 Education Program activities to other NASA Higher Education Program options that encourage and facilitate student interest in future professional opportunities with NASA and its partner organizations. Such opportunities might include NASA career employment, temporary assignment, undergraduate and graduate co-op appointment; or contractor positions.

Equally important to attracting the right people is the need to train and develop that talent. Agency expenditures for training and development of the NASA workforce increased from $30 million in 1997 to over $47 million in 2000 – from 2.5 percent of salary in FY 1997 to 3.6 percent of salary in FY 2000. In addition to funding more university level courses, the Agency has made a strong investment in ensuring NASA participation in conferences and symposia, where breakthrough research and ideas are being presented and shared, as well as providing training in other core functional areas. Emphasis is being placed on "just in time" training and coaching opportunities for project leader and team members to improve project team competencies, and efforts are being initiated to establish a network of experienced practitioners who can provide mentoring and access to expertise in project management. NASA also has updated its leadership model specifying the latest cutting edge skills and behaviors required for effective leadership. The model is linked to NASA's Strategic Plan and defines skill requirements for team leaders through senior executives. NASA requested additional FY 2002 resources to expand training delivery methods and emphasize the development of e-learning alternatives that can be accessed at all locations and levels.

NASA recognizes its greatest strength is its people – essential to safe operations, mission success, and responsible stewardship of the taxpayers' dollars. The Agency will continue to pursue focused activities to position NASA as an employer of choice, recruit and retain the best talent, and provide learning and developmental opportunities for the workforce.

Additional Management Challenges

Environmental Management

The Environmental Management Division in NASA's Office of Management Systems takes a very proactive and integrated approach to environmental management. Consistent with the strategy articulated in "NASA Environmental Excellence for the Twenty-First Century," the Agency is working on the immediate priority of bringing all NASA activities into compliance with current environmental requirements, while simultaneously restoring previously contaminated sites as quickly as funds allow. Conservation and pollution prevention will be considered in all new projects and programs to minimize environmental impacts and preserve our natural and cultural resources. This approach is clearly captured in NASA's environmental vision that "we will continue as a world leader in space exploration and aeronautics while maintaining environmental excellence." The strategy for achieving this vision includes four focus areas: prevention, compliance, restoration, and conservation. In this FY 2002 performance plan, the Agency has included performance metrics in the areas of compliance (2MS1) and restoration (2MS3).

In terms of specific areas of management concern, the decommissioning of the Plum Brook Reactor and consistent implementation of the National Environmental Policy Act (NEPA) are receiving focused attention by NASA management. In fact, both issues are on NASA's Top 10 Environmental Priorities in the current Environmental Management Division FY 2001 Operating Plan, with the Plum Brook reactor ranking as the top priority. The first five priorities are concerned with mandatory requirements that characteristically have associated legal liabilities. The second five priorities emphasize "best management practices" that offer the Agency the greatest benefits in terms of efficiency, effectiveness and cost. By placing emphasis on achieving the 10 priorities, NASA will greatly improve its legal and management situation in the area of environmental management.

Specifically, regarding the Nuclear Reactor Facility Decommissioning, Sandusky, Ohio, NASA has submitted a Decontamination and Decommissioning Plan to the Nuclear Regulatory Agency for review. Further, NASA has partnered with the U.S. Army Corps of Engineers to manage the decommissioning work aspects and included the decommissioning project in our budget request. The selected contractor and subcontractors are currently completing the necessary plans and required documentation prior to starting the decommissioning work.

Regarding National Environmental Policy Act (NEPA) Implementation, NEPA requires that NASA evaluate potential environmental impacts of proposed Federal actions as early as possible in the program/planning process. Management controls need to be strengthened to ensure greater visibility of and more consistent implementation of the NEPA process. Review of existing management controls, development and advocacy of improvements, and training activities have been planned and are being initiated.

International Technology Transfer/Export Control

The challenges concerning NASA's management of international agreements, and particularly international technology transfers, have been addressed through several processes. First, NASA issued two Federal Register notices amending the NASA Federal Acquisition Regulations (FAR) Supplement in February 2000 (see 65 Fed. Reg. 10031, February 25, 2000; 65 Fed. Reg. 6915, February 11, 2000). These new NASA FAR Supplement provisions remind NASA contractors of their obligations to comply with U.S. export control laws and regulations, and also provide specific notice regarding record-keeping requirements pertaining to contractor export activities within the scope of NASA-sponsored programs. Additionally, NASA is currently reviewing those FAR Supplement provisions with a view towards further amendments, as appropriate, to elaborate on the availability of Government-authorized export license exemptions.

Second, in response to recommendations from the NASA Inspector General, NASA is clarifying the definition of "foreign national" in its foreign visitors policy to ensure appropriate and consistent use of the term in the Agency's foreign visitors review program.

Finally, NASA has established an Agency-wide foreign national management information system to process all foreign national visitors to NASA facilities. This system is a state-of-the-art secure database that allows for each NASA facility to process requests for foreign nationals' access to NASA facilities, consistent with NPG 1371.2, and further provides an on-line system for NASA Headquarters program, desk officer, and International Visitor Control Authority review and approval or denial of visitors from designated areas.

Verification/Validation

Performance plan goals, indicators, and accomplishment claims are subject to audit by a number of internal and external groups. Therefore, we must be able to prove that we accomplished what we claim we accomplished, and we need to be able to document this proof. To ensure this capability, NASA relies on a number of processes for verifying and validating performance claims.

First, whenever possible, data in support of performance claims is gleaned from and/or validated against officially-maintained databases. The data-gathering process in all cases is subject to strict oversight. The integrity of each database also is ensured through independent audits and periodic checks by internal and/or external reviewers. These databases include: the NASA Personnel Payroll System (NPPS); the Consolidated Agency Payroll and Personnel System (CAPPS); the Incident Reporting System (IRIS); the Financial and Contractual Status of Programs System (FACS); the NASA Environmental Tracking System (NETS); the Veterans Administration Workers' Compensation Database; the consolidated NASA Occupational Health Annual Cost and Staffing Report; NASA Center Personal Property Reports; and the Center Cost Avoidance Database.

Second, a number of specific verification and validation processes are in place to support performance claims in specific areas. These include the following:

1. Integrated Financial Management System (IFMS) verification and validation are based on measures in the signed Program Commitment Agreement. Non-advocate and independent reviews are conducted periodically, and the results are reported to the HQ Program Management Council (PMC) and the IFM Council.

2. Performance Based Contracts (PBCs) are verified and validated three ways. First, PBCs are sampled routinely to ensure that each meets the criteria for designation as a PBC. Second, Occupational Health Quality Assurance Audits provide data to validate contract claims in the areas of health and safety. And, third, reviewers use the FACS database for verification checks.

3. Contract awards to small and small disadvantaged businesses are documented for verification and validation in the Summary Contractor Reports (SF 295) that are reviewed during Center Procurement Management Survey data checks. In addition, the Small Business Administration and the Department of Defense Contract Management Agency conduct periodic on-site surveys to verify and validate performance claims and process integrity, and the Minority Business Resource Advisory Council and the NASA/Prime Contractor Roundtable also do periodic reviews and make recommendations for process improvements to NASA management.

4. Information Technology (IT) performance data are verified and validated by periodic reviews conducted by a number of process overseers, including NASA and Center Chief Information Officers, staff of the NASA ADP Consolidation Center (NACC), project office staff of the NASA Integrated Services Network (NISN), and project office staff of the Outsourcing Desktop Management Initiative (ODIN). In addition, NASA's IT customers are given frequent opportunities to offer evaluations and recommendations for improved IT performance.

NASA continues to seek new verification and validation techniques for on-going performance indicators and to develop additional performance indicators that can be verified and validated with precision.

MULTI-YEAR PERFORMANCE TREND
Manage Strategically Crosscutting Process

Protect the safety of our people and facilities and the health of our workforce.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Reduce the number of Agency lost workdays (from occupational injury or illness) by 5 percent from the FY 1994-96 3-year average. (#MS3) Achieve a 5% increase in physical resource costs avoided from the previous year through alternative investment strategies in environmental and facilities operations. (#MS4)	Reduce the number of Agency lost workdays (from occupational injury or illness) by 5% from the FY 1994-96 3-year average. (#0MS3) Achieve a 5% increase in physical resource costs avoided from the previous year through alternate investment strategies in environmental and facilities operations. (#0MS12)	NASA will increase the safety of its infrastructure and workforce with facilities safety improvements, reduced environmental hazards, increased physical security, and enhanced safety awareness among its employees by meeting all 5 performance indicators in this area. (#1MS1)	NASA will increase the safety of its infrastructure and the health of its workforce through facilities safety improvements, reduced environmental hazards, increased physical security, enhanced safety and health awareness, and appropriate tools and procedures for health enhancement. (#2MS1)
Assessment	#3 was green. #4 was green.	OMS3 was blue. OMS12 was blue.		

Achieve the most productive application of Federal acquisition policies.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Increase obligated funds available for Performance Based Contracts to 80% (funds available exclude grants, cooperative agreements, actions <$100,000, Small Business Innovative Research, Small Business Technology Transfer Programs, Federally Funded Research and Development Centers, intragovernmental agreements, and contracts with foreign governments or international organizations). (#MS6)	Of funds available for Performance Based Contracts, maintain PBC obligations at 80% (funds available exclude grants, cooperative agreements, actions <$100,000, SBIR, STTR, FFRDCs, intragovernmental agreements, and contracts with foreign governments or international organizations). (#0MS5)		
Assessment	Green	Green		
Annual Performance Goal and APG #	Achieve at least the congressionally mandated 8-percent goal for annual funding to small disadvantaged businesses (including prime and subcontractors to small disadvantaged businesses, Historically Black Colleges and Universities, other minority educational institutions, and women-owned small businesses). (#MS7)	Achieve at least the congressionally mandated 8% goal for annual funding to small disadvantaged businesses (including prime and subcontractors, small disadvantaged businesses, Historically Black Colleges and Universities, other minority institutions, and women-owned small businesses). (#0MS8)		
Assessment	Green	Blue		

Achieve the most productive application of Federal acquisition policies.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Enhance contract management through improved systems and information for monitoring and through an emphasis on the training of procurement personnel, and revise metrics to assess the overall health of the procurement function. (#MS9) Enhance contract management through improved systems and information for monitoring by implementing a strategy for evaluating the efficacy of procurement operations. (#MS10)		Continue to take advantage of opportunities for improved contract management by maintaining a high proportion of Performance Based Contracts and maintain a significant involvement in NASA programs of small businesses, minority institutions, and minority and women-owned businesses by meeting 2 out of 2 performance indicators in this area. (#1MS2)	Continue to take advantage of opportunities for improved contract management by maintaining a high proportion of Performance Based Contracts (PBCs). (#2MS2) Continue integrating small, small disadvantaged, and women-owned businesses together with minority universities into the competitive base from which NASA can purchase goods and services. (#2MS9)
Assessment	All targets were green.		TBD	TBD

Manage our fiscal and physical resources optimally.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	Achieve 70 percent or more of the resources authority available to cost within the fiscal year. (#MS5) Complete system validation of the Integrated Financial Management Program, and complete system implementation at Marshall and Dryden. (#MS12)	Cost 70% or more of available resources. (#0MS4) Begin the implementation at NASA installations of the Integrated Financial Management System following the completion of system testing. (#0MS11)	Renew Agency's management systems, facilities, and human resources through updated use of automated systems, facilities revitalization, and personnel training by meeting 4 out of 7 performance indicators in this area. (#1MS3) NOTE: This target is also a precursor to #2MS7 and #2MS8.	Revitalize Agency facilities and reduce environmental liability. (#2MS3) Improve the Agency's financial management and accountability. (#2MS10)
Assessment	#MS5 was green. #MS12 was red.	OMS4 was green. OMS11 was red.	TBD	TBD

Enhance the security, efficiency, and support provided by our information technology resources.

	FY99	**FY00**	**FY01**	**FY02**
Annual Performance Goal and APG #	Improve information technology infrastructure service delivery to provided increased capability and efficiency while maintaining a customer rating of "satisfactory" and holding costs per resource unit to the FY 1998 baseline. (#MS8) Complete remediation of mission-critical systems by March 1999, consistent with Government-wide guidance for the Year 2000. (#MS11)	Improve information technology infrastructure service delivery to provide increased capability and efficiency while maintaining a customer rating of "satisfactory" and holding costs per resource unit to the FY 1998 baseline. (#0MS10)	Improve IT infrastructure service delivery to provide increased capability and efficiency while maintaining a customer rating of "satisfactory," and enhance IT security through a reduction of system vulnerabilities across all NASA centers, emphasizing IT security awareness training for all NASA personnel, by meeting 2 out of 2 performance indicators in this area. (#1MS4)	Improve IT infrastructure service delivery by providing increased capability and efficiency while maintaining a customer rating of satisfactory. (#2MS4) Enhance IT security by meeting established performance indicators in three critical areas: vulnerabilities detected, training, and IT security plans. (#2MS5) Enhance mission success through seamless, community-focused electronic service delivery. (#2MS6)
Assessment	All targets were green.	OMS10 was green.		

Invest wisely in our use of human capital, developing and drawing upon the talents of all our people.

	FY99	**FY00**	**FY01**	**FY02**
Annual Performance Goal and APG #	Reduce the civil service workforce to below 19,000. (#MS1) Maintain a diverse NASA workforce through the downsizing efforts. (#MS2)	Reduce the civil service workforce to below 18,200. (#0MS1) Maintain a diverse NASA workforce through the downsizing efforts. (#0MS2)	Renew Agency's management systems, facilities, and human resources through updated use of automated systems, facilities revitalization, and personnel training by meeting 4 out of 7 performance indicators in this area. (#1MS3) NOTE: This target is also a precursor to #2MS3 and #2MS10.	Align management of human resources to best achieve Agency strategic goals and objectives. (#2MS7) Attract and retain a workforce that is representative at all levels of America's diversity. (#2MS8)
Assessment	All targets were green.	OMS1 was no longer applicable. OMS2 was green.		

Manage Strategically FY 2002	Budget Category	HEDS	Biological and Physical Research	Aero-Space Technology	Space Science	Earth Science	Research & Program Management
Annual Performance Goals							
2MS1: NASA will increase the safety of its infrastructure and the health of its workforce through facilities safety improvements, reduced environmental hazards, increased physical security, enhanced safety and health awareness, and appropriate tools for health enhancement.		X	X	X	X	X	X
2MS2: Continue to take advantage of opportunities for improved contract management by maintaining a high proportion of Performance Based Contracts (PBCs).		X	X	X	X	X	X
2MS9: Continue integrating small, small disadvantaged, and women-owned business together with minority universities into the competitive base from which NASA can purchase goods and services.		X	X	X	X	X	X
2MS3: Revitalize Agency facilities and reduce environmental liability.		X	X	X	X	X	X
2MS10: Improve the Agency's financial management and accountability.		X	X	X	X	X	X
2MS4: Improve IT infrastructure service delivery by providing increased capability and efficiency while maintaining a customer rating of satisfactory.		X	X	X	X	X	X
2MS5: Enhance IT security by meeting established performance indicators in three critical areas: Vulnerabilities Detected; Training; and IT Security Plans.		X	X	X	X	X	X
2MS6: Enhance mission success through seamless, community-focused electronic service delivery.		X	X	X	X	X	X
2MS7: Align management of human resources to best achieve Agency strategic goals and objectives.		X	X	X	X	X	X
2MS8: Attract and retain a workforce that is representative at all levels of America's diversity.		X	X	X	X	X	X

Provide Aerospace Products and Capabilities Crosscutting Process

Mission

The Provide Aerospace Products and Capabilities (PAPAC) process is the means by which NASA's Strategic Enterprises and their Centers deliver systems (ground, aeronautics, space), technologies, data, and operational services to NASA customers. Through the use of Agency facilities, customers can conduct research, explore and develop space, and improve life on Earth. This process is used to answer the Agency's fundamental question: "What cutting-edge technologies, processes, techniques, and engineering capabilities must we develop to implement our research agenda in the most productive, economical, and timely manner?" PAPAC helps to assure that NASA strategically utilizes public resources in an efficient and effective means such that the public benefit is maximized.

Implementation Strategy

The goal of this process is to enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently. The process is also used to enable the Communicate Knowledge process to extend the technology, research, and science benefits from NASA programs broadly to the public and commercial sectors. Several of the objectives and targets address the NASA Integrated Action Team (NIAT) report actions.

Performance Measures

Goal: Enable NASA's Strategic Enterprises and their Centers to deliver products and services to customers more effectively and efficiently.

Objective - Enhance Program safety and mission success in the delivery of products and operational services.

Public Benefit: NASA's role in the advancement of research and technology is conducted through the construction and operation of facilities such as telescopes, satellites, and ground-based laboratories and test facilities. This element affects the effectiveness and efficiency with which NASA's Strategic Enterprises and Centers serve their customers.

Annual Performance Goal 2P1: Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110% of cost and schedule estimates, on average.

- Development schedule and cost data are drawn from NASA budget documentation for major programs and projects to calculate the average performance measures.

Annual Performance Goal 2P2: Track the availability of NASA's spacecraft and major ground facilities by keeping the operating time lost due to unscheduled downtime to less than 10% of scheduled operating time.

- Each field center reports the operational downtime of the major spacecraft and ground facilities.

Objective - Improve NASA's engineering capability to remain as a premier engineering research and development organization

Public Benefit: NASA's ability to improve and maintain engineering capabilities results in more efficient processes and reduced cost.

Annual Performance Goal 2P3: Strengthen the NASA engineering capability through the completion of two indicators in FY 2002.

- Complete an assessment to identify a suitable systems engineering standard for NASA. Document the standard in the appropriate NASA system (ex. NASA Procedures and Guidelines (NPG)).
- Conduct an assessment of the systems engineering capability based upon the identified systems engineering standard (NPG) to identify target areas for improvement.

Objective - Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management

Public Benefit: NASA's improvements in program and project management yields an increased number of successful missions within budget, an increase of information to the public, more technological breakthroughs, and more discoveries about our planet and universe.

Annual Performance Goal 2P4: Improve program and project management through the completion of two of the three indicators in FY 2002.

- Benchmark high-tech, successful commercial companies and government organizations and apply the results to revise NASA's program project management.
- Increase the number of program and project managers completing the Advanced Program Management Training compared to the number that completed the training in FY 2001.
- Complete the incorporation of NIAT actions into NASA policy.

Annual Performance Goal 2P5: Capture a set of best practices/lessons learned from each Program, to include at least one from each of the four PAPAC subprocesses, commensurate with current program status.

- Lessons learned from the PAPAC subprocesses are collected and utilized in process improvement and project and program training by the Program Management Council Working Group (PMCWG) and Code FT (Training and Development Division).

Objective - Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable

Public Benefit: The percentage of NASA's R&D budget dedicated to commercial partnerships affects integrated technology planning and development with NASA partners. This reduces the taxpayer cost while increasing products and services to the consumer.

Annual Performance Goal 2P6: Dedicate 10 to 20 percent of the Agency's Research & Development budget to commercial partnerships.

- Each of the Enterprises reports contribution to commercial partnerships.

Verification and Validation

Data will be verified by collaborating with the Enterprises and Centers, and during the Quarterly Status Reviews and monthly status reports.

Data will be validated by various independent assessments of program/project activity, and the review of several Center and Agency databases.

MULTI-YEAR PERFORMANCE TREND

Provide Aerospace Products and Capabilities (PAPAC)

Enhance Program safety and mission success in the delivery of products and operational services.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and Goal #	P1: Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110% of cost and schedule estimates, on average.	0P1: Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110% of cost and schedule estimates, on average.	1P1: Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110% of cost and schedule estimates, on average.	2P1: Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110% of cost and schedule estimates, on average.
Assessment	Green	Red	TBD	TBD
Annual Performance Goal and Goal #	P2: Set up process to determine, on average, the operating time of NASA's spacecraft and ground facilities lost to unscheduled downtime. Establish a baseline in FY99.	0P2: Ensure the availability of NASA's spacecraft and facilities by decreasing the downtime relative to FY1999 spacecraft and facility performance.	1P3: Ensure the availability of NASA's spacecraft and major ground facilities by keeping the operating time lost due to unscheduled downtime to less than 10% of scheduled operating time.	2P2: Track the availability of NASA's spacecraft and major ground facilities by keeping the operating time lost due to unscheduled downtime to less than 10% of scheduled operating time.
Assessment	Green	Blue	TBD	TBD
Annual Performance Goal and Goal #			Develop and approve NASA policy for Software Independent Verification and Validation, and conduct an evaluation of projects for its application through achievement of three indicators. (1P7)	
Assessment			TBD	

Improve NASA's engineering capability to remain as a premier engineering research and development organization

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and Goal #	P8: Set up process to improve engineering skills and tools within the Agency.			2P3: Strengthen the NASA engineering capability through the completion of two indicators in FY02.
Assessment	Yellow			TBD

Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management

Annual Performance Goal and Goal #				2P4: Improve program and project management through the completion of two of three indicators in FY02.
Assessment				TBD
Annual Performance Goal and Goal #	P5: Set up a process in FY99 to capture a set of best practices/lessons learned from each Program, to include at least one from each of the four PAPAC subprocesses, commensurate with current program status.	0P5: Capture a set of best practices/lessons learned from each Program, to include at least one from each of the four PAPAC subprocesses, commensurate with current program status. Inputs will be used in PAPAC process improvement and in Program/Project Management training.	1P4: Capture a set of best practices/lessons learned from each Program, to include at least one from each of the four PAPAC subprocesses, commensurate with current program status. Inputs will be used in PAPAC process improvement and in Program/Project Management training.	2P5: Capture a set of best practices/lessons learned from each Program, to include at least one from each of the four PAPAC subprocesses, commensurate with current program status.
Assessment	Green	Yellow	TBD	TBD

Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and Goal #	P6: Set up a process to determine percent of Agency's R & D budget dedicated to commercial partnerships and establish a baseline.	0P6: Dedicate the percentage of the Agency's R&D budget that is established in the FY00 process to commercial partnerships.	1P5:Dedicate 10 to 20 percent of the Agency's Research & Development budget to commercial partnerships.	2P6: Dedicate 10 to 20 percent of the Agency's Research & Development budget to commercial partnerships.
Assessment	Green	Blue	TBD	TBD

Enable technology planning, development, and integration driven by Strategic Enterprise customer needs

Annual Performance Goal and Goal #	P7: Set up a data collection process to determine the amount of leveraging of the R and D budget with activities of other organizations. Establish a baseline in FY99.	0P7:Increase the amount of leveraging of the technology budget with activities of other organizations, relative to the FY99 baseline that is established during process development.	1P6: Complete redefinition of the NASA Technology Plan to emphasize investments in the emerging strategic cross-Enterprise technology areas & include roadmaps for each Enterprise to show how Enterprise technology investments are linked to future mission needs.	
Assessment	Green	Green	TBD	

Provide Aerospace Products and Capabilities (PAPAC)	Budget Category	Space Science	Earth Science	Biological and Physical Research	HEDS	Aero-Space Technology	Research & Program Management
Annual Performance Goal and APG#							
Meet schedule and cost commitments by keeping development and upgrade of major scientific facilities and capital assets within 110% of cost and schedule estimates, on average. (2P1)		X	X	X	X	X	
Track the availability of NASA's spacecraft and major ground facilities by keeping the operating time lost due to unscheduled downtime to less than 10% of scheduled operating time. (2P2)		X	X	X	X	X	X
Strengthen the NASA engineering capability through the completion of two indicators in FY02. (2P3)							X
Improve program and project management through the completion of two of three indicators in FY02. (2P4)							X
Capture a set of best practices/lessons learned from each Program, to include at least one from each of the four PAPAC subprocesses, commensurate with current program status. (2P5)		X	X	X	X	X	X
Dedicate 10 to 20 percent of the Agency's Research & Development budget to commercial partnerships. (2P6)		X	X	X	X	X	

Communicate Knowledge Crosscutting Process

Mission

NASA communicates knowledge by coordinating, managing and sharing information and experiences related to the content, relevance, results, applications, and excitement of NASA's mission. The Communicate Knowledge (CK) process facilitates the distribution of information on NASA's missions and discoveries. It ensures increased public understanding of science and technology, promotes the application of NASA-generated information, and inspires achievement and innovation. The process ensures that knowledge derived from NASA research programs is available to meet the specific needs and interests of constituent groups. It begins at the inception of a research project and increases in intensity as the effort reaches maturity to ensure the appropriate delivery, archiving, and future convenient access of all research results. The goal of the Communicate Knowledge Process is to ensure that NASA's customers (including scientists and technologists around the world, companies and innovators, educators, publishers, museums, the media, and every citizen) receive information derived from the Agency's efforts in a timely and useful form.

Implementation Strategy

The Agency will work to expose more people to the activities of NASA's Aeronautics and Space programs by maintaining an exhibits loan service, a fine-arts program, and by providing live satellite interviews with astronauts, program managers, and other Agency officials. Through increased availability of documentation and digital images, the Agency will provide scientists and the public greater access to NASA generated knowledge. Scientific Technical Information (STI) is a service that provides for collection, organization, and archiving of NASA's STI and as such, is a unique resource to the public. The Agency will also improve utility of NASA World Wide Web pages and ease of locating areas of interest - based on the public's demand. NASA will increase the opportunities for transferring technology to private industry and the public through the Internet using the *NASA TechTracS* database, by producing a series of technology publications, and by attending industry specific conferences and trade shows. The Agency involves the educational community in its endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds. This will be accomplished by providing opportunities for students and educators at all levels to become involved in our mission; providing excellent and valuable education programs and services as judged by our customer, the education community; increasing the number of sites that offer science and engineering curriculum to the underrepresented and minority students; and increasing the involvement of minority universities through sponsored research projects.

The Objectives described in the NASA Strategic Plan for this cross-cutting process are:

- Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable
- Disseminate scientific information generated by NASA programs to our customers
- Transfer NASA technologies and innovations to private industry and the public sector
- Support the Nation's education goals

Performance Measures

The Agency has defined 4 CK Annual Performance Goals for Fiscal Year 2002. Each goal has specific indicators that will provide a quantitative manner to measure performance. The goals are listed in the text below.

Goal: Ensure that NASA's customers receive information from the Agency's efforts in a timely and useful form.

Objective: Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable.

Public Benefit: American citizens can experience NASA in ways that are meaningful and useful to them, by participating in NASA supported events.

Annual Performance Goal 2CK1: Share the experience of expanding the frontiers of air and space with the public and other stakeholders by meeting 4 of the 5 indicators for this goal.

- More Americans can visit a NASA exhibit, through a minimum of 350 events per year.
- Public attendance and participation in the NASA Art Program will increase, through exhibitions in 15 additional states.
- Agency officials and astronauts will convey clear information on NASA activities through the most used media in America: television, through no less than 20 live shots per month on average.
- NASA's activities and achievements will be chronicled and put into perspective for the American public, through 10 new historical publication.
- Documents significant in the Agency's history will be made available to a larger audience by producing one, new electronic document – a CD/ROM.

Objective: Disseminate scientific information generated by NASA programs to our customers.

Public Benefit: The public will have greater access to increased, relevant and understandable scientific information, which will enable them to share in the excitement of discovery.

Annual Performance Goal 2CK2: Inform, provide status, enthuse, and explain results, relevance and benefits of NASA's programs by meeting 2 of the 3 indicators for this goal.

- Effective use of the NASA Home Page to communicate knowledge about NASA's scientific and technological achievements to the public. Effectiveness will be rated by placing at least 50 stories about breaking news on science and technology discoveries.
- The History Office will create one additional on-line exhibit on the NASA History Web page.
- The History Office will meet the need for a timely and effective response to the public by meeting or exceeding 90% of the time a 15-day response standard.

Objective: Transfer NASA technologies and innovations to private industry and the public sector.

Public Benefit: General and targeted members of the public can benefit economically as well as intellectually through clear, effective communications concerning the Agency's activities.

Annual Performance Goal 2CK3: Ensure consistent, high-quality, external communication by meeting 3 of the 4 indicators for this goal.

- Effectively communicate technologies available for commercial use and technologies that have been commercialized by industry, through specific publications. Effectiveness will be measured by monitoring print and electronic distribution.
- Publish at least one industry specific, special edition of *Aerospace Technology Innovation* issue in FY 2002, to attract new readership and encourage partnerships with targeted industry sectors.
- Carry out effective NASA technology transfer market outreach to the medical device industry.
- The *NASA TechTracS* database, accessible through the Internet, will list at least 18,000 NASA technologies that are considered to be of benefit to U.S. industry and the public.

Objective: Support the Nation's education goals.

Public Benefit: The general public will have increased learning opportunities in science and technology fields through NASA sponsored programs.

Annual Performance Goal 2CK4: Using NASA's unique resources (mission, people, and facilities) to support educational excellence for all, NASA supports the Nation's education goals by meeting 3 of the 4 indicators for this performance goal.

- Provide excellent and valuable educational programs and services, maintaining an "excellence" customer service rating ranging between 4.3 and 5.0 (on a 5.0 scale) 90% of the time.
- NASA will involve the educational community in its endeavors, maintaining a level of involvement of approximately 3 million participants which include teachers, faculty, and students.
- Through meaningful partnerships, NASA will increase the amount of total funding obligation from the FY 2000 baseline for Historically Black Colleges and Universities and Other Minority Universities.
- NASA will establish an undergraduate scholarship program beginning in FY 2002.

Verification and Validation

Performance plan goals and indicators are subject to audit by internal and external groups. Thus, there needs to be a set of processes to document the metrics. Due to the broad nature of the Communicate Knowledge crosscutting process, there is a broad array of methods to verify and validate the reported metric data. These methods include the following:

1) Monthly reports from Field Centers.

2) Automatic built in statistics gathering software (web statistics).

3) On-air records & reports from NASA Field Centers television producers.

4) Field Center reports and commercially acquired video monitoring report from Burrelles.

5) Count of publications (History Office).

6) *Innovations* mail list and electronic subscription request file, recorded inventory and distribution request, and monitored Web site hits.

7) EDCATS has a multi-layered process to verify the accuracy and quality of the data collected.

a) Each program manager has access to rollup reports and to raw data, which identify the total number of records, the name of the reporter or participant, and a summary of the data. Thus, duplicate records can be identified, checked, and removed or corrected, or missing data sets can be identified and the reporter notified that they must complete their reports.

b) Each NASA-wide program manager and Center or Enterprise point of contact has access to a report which compiles all the records entered for their area of responsibility, so they can access the status of their specific program records and thus work with the program managers to correct errors or provide for missing reports. These “roll up” reports also provide data at a level of detail which permits the kind of visibility that can highlight implausible numbers so that action can be taken to make corrections where needed.

c) The EDCATS Program Manager has access to all levels of data and checks the status of data at the program level regularly, working with Agency points of contact and/or program managers to ensure the quality of data. The EDCATS software developer also checks the data and informs the EDCATS Program Manager of anomalies or suspected problems.

8) *NASA TechTracS* - The review of new technology reports and authorization for release to the public is carried out by each Center's patent counsel. A set of written procedures for this process is available upon request. The actual implementation of a release is controlled automatically when the "release to public" data field in each Centers' *TechTracS* is set to yes. Access to this data field is tightly controlled by each Center.

9) Metric data is collected by contractor as part of the contract report. Improvements are verified by a NASA representative of the STI Program Office, Principal Center for the STI Program.

10) On-site visits.

11) Counters on the web pages, reports on the numbers of information requests, monthly activity reports, e-mails, memos, letters, press releases, publications, and the NASA History Program Review which takes place each year. There is some limitation to this data in the sense that the web page counters do not document why an individual accesses the web page.

12) Listings of events, activities and products are available on the Internet. The NASA Web site, http://www.nasa.gov/, is updated daily and provides to the general public information about the most interesting information about the Agency. This Web site is the "hub" for the other NASA Web sites and provides links to all other areas of the agency. For example, there is a link to the Space Science Web site, http://spacescience.nasa.gov/, an excellent location updated daily with the latest news, pictures of space, and education activities. In addition to links to the NASA enterprises, the main NASA Web site also contains links to areas such as the education programs, the history office, human resources, research opportunities, and business opportunities. The Education Programs Web site (http://education.nasa.gov/), for example, provides to the visitor user-friendly activity calendars, and educational products and resources. Each field center also offers a central Web site with numerous links to activities, events, and products specific to the area of excellence that distinguishes each Center.

13) Reports from the NASA Centers regarding their imagery additions for the year.

14) Data are collected from participants in Agencywide, Enterprise, and Center education programs via an on-line data collection system. Program participants have the opportunity to rate our programs by answering a series of questions including, would they recommend the program to others; how would they rate the staff; do they expect to apply what was learned; and was the program a valuable experience. The ratings provided on these questions are then used to create an "overall average for excellence."

MULTI-YEAR PERFORMANCE TREND
Communicate Knowledge Crosscutting Process

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	CK9: Produce 10 new publications chronicling and placing NASA's activities and achievements in perspective for the American public. Sponsor or co-sponsor one major scholarly conference.	0C3: Produce 12 new historical publications chronicling and placing NASA's activities and achievements in perspective for the American public.	1CK1: Share the experience of expanding the frontiers of air and space with the public and other stakeholders by meeting 5 of the 6 indicators for this target.	2CK1: Share the experience of expanding the frontiers of air and space with the public and other stakeholders by meeting 4 of the 5 indicators for this goal.
Assessment	Blue	Green	TBD	TBD
Annual Performance Goal and APG #	CK10: Acquire 10,550 NASA-sponsored, -funded and/or -generated report documents for the American scientific community and public, publish 26 issues of an electronic current awareness product to announce additions to the NASA STI database, and add 24,400 bibliographic/ citation records to the online NASA STI data base.			
Assessment	Blue			

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0C12: The Office of Public Affairs is acquiring the capability to provide the media with digital, high-definition video when the broadcasting industry converts to digital broadcasting in the next decade. It will also add a searchable online digital version of the NASA Headquarters photo archive to the NASA Home Page.		
Assessment		Green		
Annual Performance Goal and APG #		0C13: The Office of Public Affairs will open exhibits to new audiences. A series of new exhibits with updated information on the Agency's four Enterprises will begin circulation. New Internet sites to inform the public of exhibits available for loan will expedite the loan process and attract new audiences. Two NASA Centers will create new exhibits and renovate visitor facilities to attract and accommodate additional visitors.	*Captured in APG (1CK1)	*Captured in APG (2CK1)
Assessment		Green		

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0C19: Maintain a baseline for live satellite interview programs of no less than 10 live shots per month.	*Captured in APG (1CK1)	*Captured in APG (2CK1)
Assessment		Blue		
Annual Performance Goal and APG #		0C20: Maintain a baseline of 5 Video File elements per week, issuing raw video and animation daily on NASA TV.		*Captured in (2CK1)
Assessment		Blue		
Annual Performance Goal and APG #		0C4: Increase the NASA-sponsored, funded, or generated report documents for the scientific community and public from 11,600 to 13,920.	*Captured in APG (1CK1)	*Captured in APG (2CK1)
Assessment		Blue		
Annual Performance Goal and APG #		0C16: Increase the nontraditional NASA-sponsored scientific and technical information through the NASA Image exchange (NIX) digital image database from 300,000 in FY98 to more than 470,000 in FY00.	*Captured in APG (1CK1)	
Assessment		Green		

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #		0C14: The History Office will target high school students through the use of a History Day competition on "Science, Technology, and Invention." The contest is being conducted in concert with the History Day Organization, with co-sponsored teacher workshops at every NASA Center.		
Assessment		Red		
Annual Performance Goal and APG #		0C6: The Office of Scientific and Technical Information Program plans to improve the NASA Image exchange (NIX) meat-search engine accessing all NASA digital image databases, adding Quick-Time, video, animation, and browse categories on NASA's key topics of interest to customers.		
Assessment		Green		

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #		Increase the number of searched pages in NASA Web space by 5% per year, relative to the FY99 baseline. (0C17)	Inform, provide status, enthuse, and explain results, relevance and benefits of NASA's programs by meeting 2 of the 3 indicators for this target. (1CK2)	Inform, provide status, enthuse, and explain results, relevance and benefits of NASA's programs by meeting 2 of the 3 indicators for this goal. (2CK2)
Assessment		Blue	TBD	TBD
Annual Performance Goal and APG #		Increase the capacity of the NASA Home Page to meet public demand by providing for a 5% per year increase in download capacity, using FY99 figures as a baseline. (0C18)	*Captured in APG (1CK2)	*Captured in APG (2CK2)
Assessment		Blue		
Annual Performance Goal and APG #		Provide the public with internal access to listings of (1) existing and upcoming communications events, activities, and products and (2) best communications practices within NASA. (0C7)		
Assessment		Red		

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #		0C21: Provide publications that will communicate technologies available for commercial use and technologies that have been commercialized by industry to facilitate technology transfer. The three principal publications are *Innovations*, (12,000), *Spin-off* (50,000), and *Tech Briefs* (205,000), whose effectiveness will be measured by monitoring readership and frequency of use as a source of reference.	Ensure consistent, high-quality, external communication by meeting 2 of the 3 indicators for this target. (1CK3)	Ensure consistent, high-quality, external communication by meeting 3 of the 4 indicators for this goal. (2CK3)
Assessment		Green		
Annual Performance Goal and APG #		0C22: Publish at least 1 industry specific *Aerospace Technology Innovation* issue per year.	*Captured in APG (1CK3)	*Captured in APG (2CK3)
Assessment		Blue		

Improve the external constituent communities' knowledge, understanding, and use of the results and opportunities associated with NASA programs (FY 1999, 2000, and 2001)/Share with the public the knowledge and excitement of NASA's programs in a form that is readily understandable (FY 2002).

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #		0C15: The Office of Aero-Space Technology's *Aerospace Technology Innovation* Publication will be targeting medical facilities for new readership, as well as the automotive industry for new technology transfer opportunities. The organization will attend the Society for Automotive Engineers annual tradeshow in Detroit, Michigan.		*Captured in APG (2CK3)
Assessment		Red		

Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to directly participate in space research and discovery.

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	CK1: Increase the number of educators who participate annually in NEWEST/NEWMAST) to 500 from 400 in FY 98.			
Assessment	Green			

Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to directly participate in space research and discovery.

	FY 1999	**FY 2000**	**FY 2001**	**FY 2002**
Annual Performance Goal and APG #	CK2: Increase the number of students reached through the NEWEST/NEWMAST program to 42,000 students from 33,600 in FY 98.			
Assessment	Green			

Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to directly participate in space research and discovery (FY 1999, 2000, and 2001)/Support the Nation's education goals (FY 2002).

Annual Performance Goal and APG #	CK3: Maintain the participation level in Agency-wide educational programs at more than 1 million teachers and students.	0C1:Seek to maintain a level of participation involvement of approximately 3 million with teachers, faculty, and students in the education community.	1CK4: Use NASA's ability to support meeting the Nation's education goals by meeting 3 of the 4 indicators for this target.	2CK4: Using NASA's unique resources (mission, people, facilities) to support educational excellence for all, NASA supports the Nation's education goals by meeting 3 of the 4 indicators for this performance goal.
Assessment	Blue	Blue	TBD	TBD

Highlight existing and identify new opportunities for NASA's customers, including the public, the academic community, and the Nation's students, to directly participate in space research and discovery (FY 1999, 2000 and 2001)/Transfer NASA technologies and innovations to private industry and the public sector (FY 2002).

	FY 1999	FY 2000	FY 2001	FY 2002
Annual Performance Goal and APG #	CK12: Increase new technology opportunities from 19,600 to 19,700. These will be made available to the public through the NASA TechTracs database and will be measured by monitoring a controlled data field that indicates the number of new technologies communicated to the public.	0C9: Increase new opportunities to transfer technology developed at NASA to private industry from 19,600 to 19,800. These opportunities will be made available to the public through the NASA TechTracs database and will be measured by monitoring a controlled data field that indicates the number of new technologies communicated to the public.	*Captured in APG (1CK3)	*Captured in (2CK3)
Assessment	Blue	Green		
Annual Performance Goal and APG #		0C10: Assist customers who use the STI Help Desk and the NASA Image exchange (NIX) digital image database within a specific turnaround period.	*Captured in APG (1CK2)	
Assessment		Green		
Annual Performance Goal and APG #		Support no less than 800 portable exhibit loans and send portable exhibits to a minimum of 175 targeted events per year. (0C11)		
Assessment		Blue		

Communicate Knowledge FY 2002	Budget Category	Space Science *	Earth Science *	Biological and Physical Research	HEDS *	Aero-Space Technology *	Academic Programs	Research & Program Management
Annual Performance Goal and APG#								
Share the experience of expanding the frontiers of air and space with the public and other stakeholders by meeting 4 of the 5 indicators for this goal. (2CK1)		x	x	x	x	x		x
Inform, provide status, enthuse, and explain results, relevance and benefits of NASA's programs by meeting 2 of the 3 indicators for this goal. (2CK2)		x	x	x	x	x		x
Ensure consistent, high-quality, external communication by meeting 3 of the 4 indicators for this goal. (2CK3)						x		
Using NASA's unique resources (mission, people, and facilities) to support educational excellence for all, NASA supports the Nation's education goals by meeting 3 of the 4 indicators for this performance goal. (2CK4)		x	x	x	x	x	x	

* The Enterprises also have specific APGs and indicators dealing with Communicating Knowledge.