# NASA Performance Report

Fiscal Year 2001

National Aeronautics and Space Administration

# Message From the Administrator

*This is to present the National Aeronautics and Space Administration Fiscal Year 2001 Performance Report.*

*In FY 2001, NASA achieved 79 percent of the annual performance goals that mark progress toward achieving our strategic objectives. In achieving these goals, we have advanced the scientific understanding of Earth, the solar system, and the universe; pursued human exploration and development of space; and developed revolutionary technologies that will carry us forward in the years to come.*

*FY 2001 was a year of challenge as well as achievement. To help address those challenges, the Agency is recommitting itself to ensure that its managerial expertise as well as technical expertise is strong. We will broaden our efforts to optimize financial, personnel, and contractual capabilities. Data that allow us to identify areas where improvement is needed will be used to forge new policies and procedures. By focusing on our management capabilities, it is likely that the Agency will be able to achieve more scientifically and technically.*

*In science and technology, NASA will emphasize the fundamentals by focusing on those areas where the Agency has specialized expertise and capabilities. Data that show where NASA has met or exceeded its scientific and technical performance goals will be used to define those areas of strength for application to areas of lower performance.*

*It is from these lessons that NASA is developing the means for moving ahead, furthering its potential for achievement while providing a better return on the public's investment.*

*Sean O'Keefe*
*Administrator*

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# The Agency

*NASA is a Federal agency that provides Americans with the science, technology, and operations we need to understand and explore the furthest reaches of space and use the vantage point of space to understand and improve life on Earth. We provide data and information to scientists and engineers; advanced software and hardware concepts and systems to governmental, academic, and commercial endeavors; and educational expertise and materials for all levels of formal and informal learning communities worldwide. The Agency's primary areas of endeavor are space science, Earth science, biological and physical research, human exploration and development of space, and aerospace technology.*

*Our core structure consists of a headquarters in Washington, DC; 10 Field Centers located in Maryland, Virginia, West Virginia, Florida, Ohio, Alabama, Mississippi, Texas, and California; and various facilities across the Nation. The Agency has a workforce of approximately 18,000 full time civil service employees, supplemented by academic and commercial contractors, and has a budget of approximately $14 billion.*

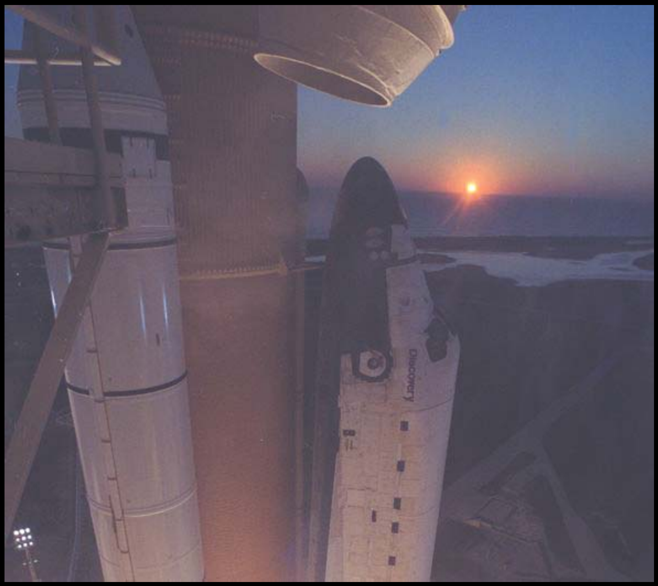
# NASA's History

*In 1915, when aviation was still in its infancy, the U.S. Congress created an organization that would "supervise and direct the scientific study of the problems of flight, with a view to their practical solutions." That organization, the National Advisory Committee for Aeronautics (NACA), evolved into the National Aeronautics and Space Administration (NASA) 4 decades later, when Congress formed a civilian agency to lead "the expansion of human knowledge of phenomena in the atmosphere and space." The journey begun in 1915 has taken American aviators, astronauts, and robotic spacecraft from the dunes of Kitty Hawk to the edge of the atmosphere and to the surface of the Moon and Mars. Americans and their spacecraft have explored more than 60 worlds in our solar system, while methodically peering back in space and time to reveal many of the secrets of the universe. They have used the environment of space to explore fundamental biological and physical processes and used the vantage point of space to gain a better understanding of the complex environmental systems in which we live.*

**NASA to determine if humans can survive in space**

7 October 1958. The new National Aeronautics and Space Administration announced Project Mercury, its first major undertaking. The objectives were to place a manned spacecraft into orbital flight around Earth, observe human performance in such conditions, and recover the human and the spacecraft safely. At this early point in the U.S. space program, many questions remained. Could a human function ably as a pilot-engineer-experimenter in the harsh conditions of weightless flight? If yes, who were the right people for the challenge? The original Mercury astronauts are shown here.

# NASA's Vision



**NASA prepares for the dawn of a new day**

8 March 2001. The Sun peered over the eastern horizon before the Space Shuttle Discovery's morning launch on mission STS-102. The mission included delivering supplies and crew to the International Space Station.

- *To improve life here*
- *To extend life to there*
- *To find life beyond*

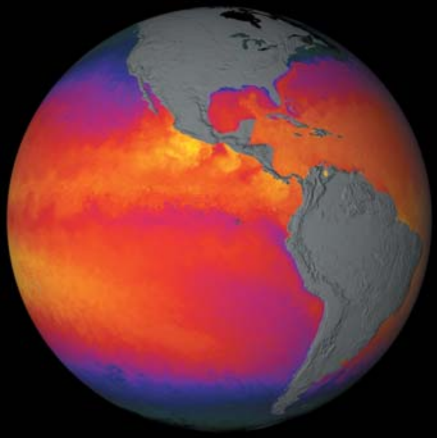
# NASA's Mission

- *To understand and protect our home planet*
- *To explore the universe and search for life*
- *To inspire the next generation of explorers*

*. . . as only NASA can*

**NASA has a long timeline between concept and achievement**

Over the last 30 years, scientists have observed disturbances such as El Niño/La Niña and Pacific Warm Pool Oscillations that occur within the climate system on different time scales, ranging from years to decades. Yet scientists do not know to what degree changes in the frequency and severity of these phenomena may be due to climate change or whether they represent the system's natural variability. A sensor orbiting the Earth aboard NASA's Terra satellite is now collecting the most detailed measurements ever made of the sea's surface temperature every day all over the globe. The image to the right, obtained between January 1-8, 2001, shows cold water surging up near the coast of Peru (purple) and joining the South Equatorial Current, which flows westward across the Pacific Ocean.



# The Nature of NASA's Work

*In our pursuit of research and development, NASA has historically been one of the most visible Federal agencies in terms of performance. Public attention is drawn quickly to program successes and even more quickly to program failures. Press conferences on the scientific results and program technical status are commonplace. However, with all the emphasis on dramatic breakthroughs, and sometimes, heartbreaking failures, it is easy to forget the true nature of both. It is essential to consider two integral attributes of the work NASA performs before evaluating our performance: the high-risk nature of the work and the long timeline between concept and achievement.*

*NASA's endeavors are, by nature, high-risk: If NASA is not taking risks, it is not doing its job. It is by seeking to achieve the seemingly unachievable that NASA succeeds in developing missions that produce leaps in scientific understanding and revolutionary technologies. Our goals are inherently ambitious. NASA, for example, is key to flying the largest and most complex research spacecraft ever built—the International Space Station. This new star in the night sky is now the size of a three-bedroom house with 10 times the electrical power produced by solar panels that exceed the wingspan of a 777 wide-body jet and power a wide range of biological, medical, materials, and commercial experiments. Spacewalking astronauts recently completed the most challenging mission ever undertaken to service the Hubble Space Telescope. During five spacewalks, astronauts replaced old faltering equipment, added a powerful new camera and installed an experimental cooling device needed for another camera. Before such endeavors can be achieved, NASA has to find ways to mitigate the risks, sometimes with surprising results and unanticipated alternatives. At NASA, a schedule slip does not necessarily represent a failure, but rather a wise decision to reduce uncertainty by pushing to new technological frontiers.*

*In addition, many NASA programs also have an unusually long timeline. We are currently supporting basic research in areas such as astrobiology and physics that have no clear endpoints, planning to build spacecraft that we expect to arrive at the outer reaches of the solar system sometime before 2020, and studying global environmental systems that will predict what Earth will be like not only in the coming decades but in the coming centuries.*

# The Public Investment

*Over the past 3 years, NASA's total budget ranged between $13.7 and $14.3 billion. Distribution of funds across categories remained relatively constant.*

| Category | Budget | | | | | |
|---|---|---|---|---|---|---|
| | Dollars (Millions) | | | Percent | | |
| | FY 1999 | FY 2000 | FY 2001 | FY 1999 | FY 2000 | FY 2001 |
| Space Science | 2,119 | 2,524 | 2,607 | 16 | 19 | 18 |
| Earth Science | 1,414 | 1,690 | 1,762 | 10 | 12 | 12 |
| Biological and Physical Research | 264 | 340 | 362 | 2 | 3 | 3 |
| Human Exploration and Development of Space | 6,045 | 7,011 | 7,106 | 44 | 52 | 50 |
| Aerospace Technology | 1,339 | 1,834 | 2,213 | 10 | 13 | 16 |
| Other* | 2,472 | 202 | 203 | 18 | 1 | 1 |
| **Total Budget** | **13,653** | **13,602** | **14,253** | **100** | **100** | **100** |

* For FY 1999, the "Other" category includes research and program management, academic programs, facilities construction, the Office of Inspector General, and safety and mission assurance. For FY 2000 and FY 2001, this category includes only academic programs, the Office of Inspector General, and safety and mission assurance.

# The Public Benefits

*Two of the questions most frequently asked about NASA are:*

- *Why go into space when we have so many problems here on Earth?*
- *What does the space program do for me?*

*These are questions that need to be answered and are addressed on the following pages.*


**Launches support our ability to conduct research in space**

10 August 2001. As Space Shuttle Discovery roars into the blue sky over the Space Coast, the brilliant flames of its engines and boosters cast a pink glow on the water. The spectators across the water enjoy the spectacle for on-time liftoff at 5:10:14 p.m. EDT. Besides the Shuttle crew of four, Discovery carries the Expedition 3 crew that will replace Expedition 2 on the International Space Station. The mission includes the third flight of an Italian-built Multi-Purpose Logistics Module delivering additional scientific racks, equipment, and supplies for the Space Station; and two spacewalks. The three-member Expedition 2 crew will be returning to Earth aboard Discovery after a 5-month stay on the Station.

**NASA builds scientists and engineers**

19 September 2001. In grade school, Alexis never dreamed of becoming an astronaut, scientist or engineer. Today, the teenager is leading work on a low-gravity science experiment that will be launched on a rocket built by other teens—part of the Student Launch Initiative at NASA's Marshall Space Flight Center. "Marshall's Student Launch Initiative is using rocketry to fuel learning," says the Marshall Center Director. "It's exciting to see how the students are motivated to think in original ways when they've been challenged to figure out how to build and launch a rocket."

# Primary Benefits

*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 other Federal agencies, the academic world, and industry 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 planetary system to understand and predict its behavior, 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. The unique character of NASA's mission has the ability to captivate the imagination of students and educators. NASA channels the adventures of Martian rovers, the excitement of spacewalking astronauts, and the exotic beauty of space imagery into education endeavors that support local, state, and national education priorities. From pre-kindergarten through post-graduate studies, NASA provides opportunities for students of all ages to get involved with NASA's scientists and engineers, special facilities, and research and development activities. In FY 2001, the Agency provided approximately 4 million teachers, faculty and students access to NASA's Education Program in addition to the discipline specific efforts sponsored by NASA's science enterprises. A total of $24 million was awarded for research in the Minority Universities Research and Education Program in addition to the discipline specific efforts sponsored by NASA's science Enterprises. NASA educational efforts embrace the diversity that is the Nation's strength.*
- ***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.*

# Secondary Benefits

*Technology developed for space flight has produced thousands of spinoffs for applications that contribute to the national economy, productivity, and lifestyle. It is almost impossible to find an area of everyday life that has not been improved by space-based technology. These secondary applications represent a substantial return on the national investment in NASA. Recent examples include:*

- ***Medical Diagnostics and Treatment.*** *Mars Pathfinder technology developed to enhance pictures obtained in space is being modified to make three-dimensional models of breast tissue. Combining ultrasound with advanced computing, the imaging device discerns cancerous from healthy tissue by comparing changes in shape and analyzing the ultrasound signal. This enables doctors to differentiate tissue more accurately without using painful invasive procedures.*

- ***Environmental Monitoring.*** *Sensors for satellite monitoring of greenhouse gases in the Earth's atmosphere are being used to detect lethal chemical agents on Earth. This will not only improve the ability of the U.S. government to respond to the potential domestic threat posed by terrorist groups, but it will also aid military personnel in combat situations abroad. Also, the technology has the potential to detect the by-products of drug manufacturing operations, which could make drug interdiction efforts more productive and cost effective.*

- ***Training System Technology.*** *A training system originally developed to facilitate astronaut adaptation to space through a combination of autogenic therapy and biofeedback can now be used by commercial and private pilots to reduce the risk of human error accidents by helping to control the physiological arousal associated with emergency flying conditions. The system can also be used in the treatment of hypertension, dysautonomia, autonomic neuropathy, and nausea associated with chemotherapy.*

- ***Complex Project Management.*** *A schedule and cost risk analysis modeling system, originally developed in response to NASA's need to identify the importance of major delays in Shuttle ground processing, is now available to help analyze schedule and cost risks in a range of complex projects. This technology could save industries millions of dollars by helping them improve project management processes and identify the best process improvements to reduce bottlenecks and inefficiencies.*

- ***Highway Transportation.*** *Subsonic aerodynamic design principles have been applied to highway vehicles to reduce drag. These principles have also been applied to improve livestock transportation, where a combination of overheating, ingestion of dust and fumes, and uneven ventilation contributes to shipping fever, a fatal respiratory disease. NASA's energy-efficient livestock hauler provides a healthier, more humane environment through a positive, monitored, controlled ventilation system. It overcomes ventilating and heat problems while lowering fuel consumption.*

**NASA's space technology is used to treat cancer patients**

Growing plants on the Space Shuttle, NASA demonstrated that light-emitting diodes can stimulate cell growth. Now, the same diodes used to grow plants in space are being used to treat mouth sores resulting from cancer treatment. In the image, a medical student (left) times a treatment administered by a nurse practitioner (right) at the Children's Hospital of Wisconsin in Milwaukee. The 15-year-old cancer patient (center) is one of hundreds of patients who participated in the study. The light-emitting diodes are also being studied for a variety of other wound-healing applications.

# Institutionalizing Public Benefits

*In recent years, NASA has worked to institutionalize the practical benefits derived from its core programs. The Earth Science Enterprise, for example, has established an Applications Division. The division's goals are to use NASA's scientific and technical capabilities to develop better operational tools for the public and private sector decision makers, stimulate public interest in and understanding of Earth system science, and encourage young scholars to consider careers in science and technology.*

*The applications are organized around four themes:*

- ***Resource management.** Over 70 projects involve over 100 partnerships that use NASA-sponsored science and technologies in management of renewable and nonrenewable resources, such as agriculture, forestry, range lands, fisheries, and energy.*
- ***Disaster management.** Over 100 projects use NASA-sponsored science and technologies in assessment and mitigation of natural disasters, such as wildfires, earthquakes, volcanic eruptions, landslides, subsidence, severe storms and floods, adverse coastal changes, and examination of the impact of the environment on human health.*
- ***Community growth and infrastructure.** More than 20 projects address transportation, infrastructure, utilities, conservation and preservation of recreational resources, urban planning, and land use practices.*
- ***Environmental assessment.** Over 20 projects examine air, water, land environments, ecosystems, and the effect of natural and human-made changes on these environments.*

**NASA's Earth Science Applications Division ensures down-to-Earth benefits**

To help American farmers better compete in the world market, NASA and the U.S. Department of Agriculture started the Ag 20/20 program in 2000. A 7,200-acre cotton farming operation in Louisiana is one of the program's sites. NASA researchers are teaming with Louisiana State University to use digital photographs taken from an airplane or satellite to determine where in a field the farmer needs to apply such things as pesticides or plant growth regulators. The images are used to create a color vegetation index map that separates the field into several categories of vegetation health.

Using handheld computer systems (shown below) similar to personal data assistants, downloaded images are matched with Global Positioning System data to give their exact location on the farmland grid. The researchers determine what areas need to be sprayed. Then they transmit insect infestation data back to the Stennis Space Center, Mississippi. From there, the researchers work with the farmer to determine an exact insecticide prescription to apply—one that adequately controls the insect pressures while saving the farmer money on labor and chemicals.

**NASA works to reduce aircraft failure rates**

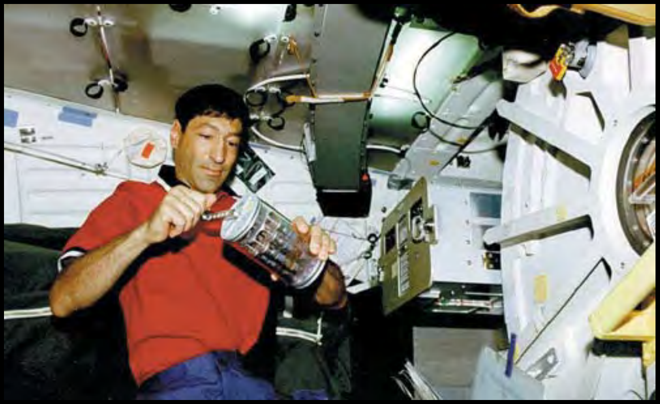
NASA is developing the Aircraft Condition Analysis and Management Systems to ensure that only "healthy" aircraft are flown. In a ground demonstration using the NASA Boeing 757 test aircraft, the systems' logic successfully identified faults and provided an assessment of the impact on continued airworthiness of the aircraft prior to the conditions resulting in critical failure levels.

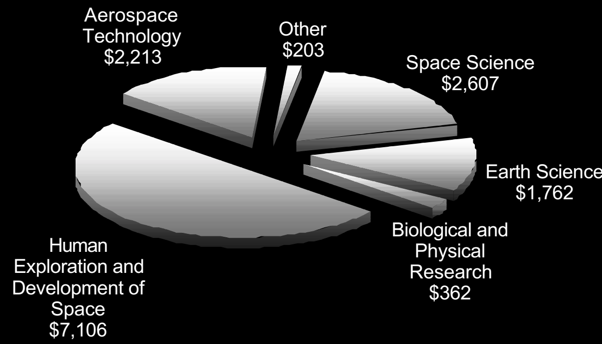
*Similarly, NASA's aerospace technology effort has always focused on practical benefits. Over the past 75 years, aerospace technology research and development has fostered the economic growth of our Nation, provided unprecedented mobility for U.S. citizens, and ensured our national security. As demonstrated by the events of September 11, 2001, a modern air and space transportation system is fundamental to the economy, quality of life, and security of the United States.*

*Finally, NASA has established programs that ensure that the Agency's public benefits are integrated into our Nation's economy.The International Space Station Opportunity Program, for example, is aimed at stimulating business investment in the development of new markets and industries in low-Earth orbit. The Agency envisions three broad categories of opportunities: utilization, operations, and new capability development. Within each area, NASA will use its position as both a customer and a service provider to incubate new commercial space businesses, and let the market take over when the businesses reach profitability. NASA has committed to set aside approximately 30 percent of the U.S. share of the Space Station's research capacity for commercial use.*

**NASA begins space commercialization**

One of the first commercial experiments aboard the Space Station, the study of antibiotic production in space, is shown here. Bristol-Myers Squibb Pharmaceutical Research Institute is collaborating with one of NASA's Commercial Space Centers—BioServe Space Technologies at the University of Colorado at Boulder. BioServe is 1 of 11 Commercial Space Centers dedicated to helping industry conduct experiments in space through NASA's Space Product Development Program at the Marshall Space Flight Center.






NASA Budget in Millions
$14,253

# NASA's Mission Is Accomplished Through Five Strategic Enterprises

- ***Space Science***
- ***Earth Science***
- ***Biological and Physical Research***
- ***Human Exploration and Development of Space***
- ***Aerospace Technology***

**NASA's purview is the Earth and its environment**

Our solar system consists of (from left to right) an average star we call the Sun, the planets Mercury, Venus, the "blue marble" that we call Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto. The whole solar system, together with the local stars visible on a clear night, orbits the center of our home galaxy, a spiral disk of 200 billion stars we call the Milky Way. The nearest large galaxy is a spiral galaxy like the Milky Way, but is 4 times as massive and is 2 million light-years away. Our galaxy, one of billions of galaxies known, is traveling through intergalactic space.

**NASA space telescope continues to increase scientific power**

The Hubble Space Telescope, launched in 1990, was the first scientific mission specifically designed for routine servicing by astronauts. It has a visionary, modular design that allows the astronaut to replace worn out equipment and upgrade instruments. The advanced camera for arrays that is being installed in 2002 will provide a factor of 10 improvement in scientific power over the instrument it is replacing.

# Space Science

*NASA's space science programs seek to chart the evolution of the universe, from origins to destiny, and understand its galaxies, stars, planetary bodies, and life. NASA space scientists seek answers to four fundamental questions that have eluded humankind throughout the course of history:*

***How did the universe begin and evolve?*** *Space science seeks to explain the earliest moments of the universe, and how stars and galaxies formed. Scientists study astrophysical objects, such as neutron stars and black holes, which demonstrate fundamental laws of physics at work. The behavior of matter, radiation, and magnetic fields in the giant laboratory of our solar system is studied, enabling us to understand the structure of the universe from its earliest beginnings to its ultimate fate.*

***How did we get here?*** *Space science investigates how the chemical elements necessary for life were built up and dispersed throughout the universe. NASA looks for evidence about how the Sun has behaved over time, and its effects on Earth. Probes are sent to other planets to learn about their similarities and differences as keys to how they formed and evolved, and to study the comets and asteroids in our solar system for clues to their effects on the evolving Earth. Space science carries out ground-based research to learn how life began and evolved on early Earth.*

***Where are we going?*** *The vulnerability of Earth to possible impacts by comets and asteroids is being investigated. Space scientists are studying the variability of our Sun and the space weather it produces in order to predict and manage its effects on communications, military and weather satellites, the electric power grid, and on humans in space. NASA will contribute to making travel throughout the solar system safe and will ascertain possible destinations that could offer important resources to human explorers.*

***Are we alone?*** *Is life on Earth an improbable accident of nature or is life scattered throughout the universe? Space science seeks to explain how planets originated around the Sun and other stars—planets that might support life. Researchers observe nearby stars for indirect evidence of other planets and look to the future when advanced observatories in space might be able to directly view such relatively small objects. They theorize about what kinds of environments could bear and support life and how common habitable planets might be.*

*Today, NASA is beginning to answer these questions. Space science employs the tools of science that range from abstract mathematics and computer modeling to laboratories and observatories to help humans in the details of the amazing story of the universe. In the last 40 years, NASA's space probes and observatories have played a central role in this fascinating process, and our research will continue to address these four profound questions.*

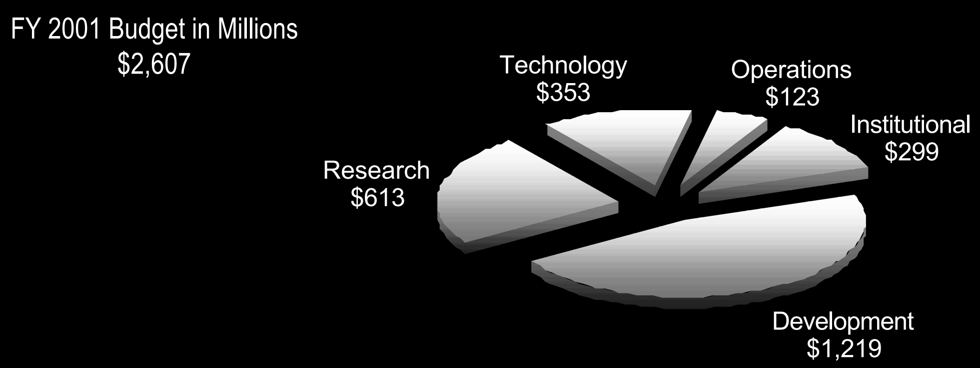
## *Strategic Goals*

1. *Chart the evolution of the universe from origins to destiny, and understand its galaxies, stars, and life*

2. *Contribute measurably to achieving the science, math, and technology education goals of our Nation*

3. *Support human exploration through robotic missions*

4. *Develop new technologies needed to carry out innovative and less costly mission and research concepts*




## *FY 2001 Performance*

*FY 2001 space science programs produced excellent results, achieving 86 percent of the annual performance goals. This is a substantial improvement over FY 2000.*

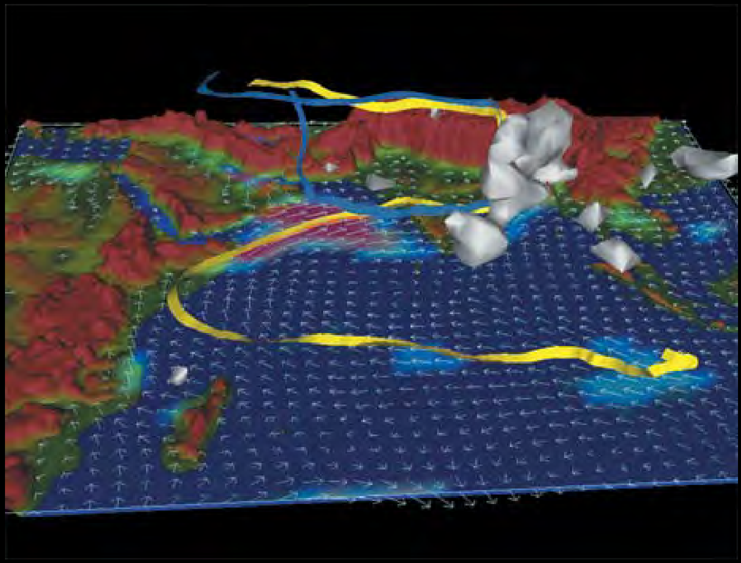
*NASA's space science effort includes forefront research and technology development on the ground, as well as development and operation of the most complex spacecraft conceived. NASA fully expects exciting surprises as the voyage of discovery continues to expand knowledge about the history and future of the universe and of humankind within it.*

# Earth Science

*NASA's Earth Science program explores how the Earth system is changing, and what the consequences of those changes are for life on Earth. To accomplish this endeavor, scientists have set out to answer the following questions:*

- *How is the global Earth system changing?*
- *What are the primary causes of the Earth system variability?*
- *How does the Earth system respond to natural and human-induced changes?*
- *What are the consequences of change in the Earth system for human civilization?*
- *How well can we predict future changes in the Earth system?*

*Through this research, NASA is dedicated to understanding the total Earth system and the effects of natural and human-induced changes on the global environment. The unique vantage point of space provides information about Earth's land, atmosphere, ice, oceans, and biota that is obtainable in no other way. NASA Earth science programs explore the interactions among these components to advance the new discipline of Earth system science, with a near-term emphasis on global climate change. Our research results contribute to the development of sound environmental policy and economic investment decisions. Innovative technologies and applications of remote sensing for solving practical societal problems in food and fiber production, natural hazard mitigation, regional planning, water resources, and national resource management, in partnership with other Federal agencies, industry, and State and local governments, are the outcome of NASA investments in the Earth science program.*



**NASA's Earth science uses space-based data to generate models of Earth systems**

This image shows a three-dimensional perspective of atmospheric flow based on data collected during an Indian monsoon. More recently, a study supported by NASA showed significant improvement in climate models to accurately reproduce weather systems such as cyclones, fronts, and jet streams. The new system realistically reproduced various circulation features related to the North Pacific and Atlantic jet streams.

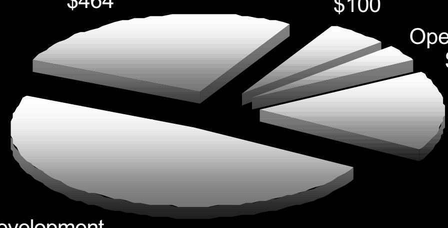
## *Strategic Goals*

1. *Expand scientific knowledge by characterizing the Earth system*

2. *Disseminate information about the Earth system*

3. *Enable the productive use of Earth science and technology in the public and private sectors*

FY 2001 Budget in Millions
$1,762




## *FY 2001 Performance*

*NASA's Earth science programs achieved 89 percent of the FY 2001 annual performance goals. This is a slight improvement from the level of performance demonstrated in FY 2000.*

*NASA anticipates exciting discoveries as efforts continue to expand our knowledge 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 uses the International Space Station as a platform for biological and physical research**

13 May 2001. The Phantom Torso, seen here in the Destiny laboratory on the International Space Station, is designed to measure the effects of radiation on organs inside the body by using a torso that is similar to those used to train radiologists on Earth.

# Biological and Physical Research

*NASA's biological and physical research seeks to answer the basic questions underlying human space flight by:*

- *Understanding nature's forces in space*
- *Understanding and enabling the human experience in space*

*The space environment offers a unique laboratory in which to study biological and physical processes. NASA scientists take advantage of this environment to conduct experiments in physics, chemistry, and biology in search of answers to basic and applied research questions. A broader program of ground-based research supports research progress in space and develops new hypotheses for testing. 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. Only in space can researchers eliminate the effects of gravity. In space, we enter a new realm of research in physics, chemistry, and biology.*

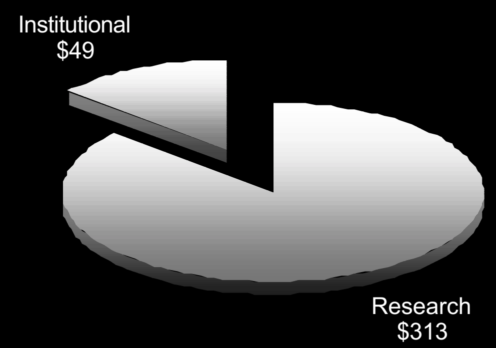
*Millions of years of evolution have molded the human body to cope with and rely upon gravity. Virtually every system of the body responds when a person travels to space. Weight-bearing bones are not needed, so the body disposes of them at a rate of about 1 percent of bone mass per month. Muscles atrophy and nerves in the balance system begin to rewire their connections to take account of the sudden disappearance of up and down. Fluids initially shift upward in the body. The immune response is suppressed. Many of these changes pose significant health issues, especially when a space traveler returns to gravity. Biological and physical researchers seek to understand these changes and to develop methods for efficiently controlling them and ensuring the health and safety of present and future space travelers. As NASA works to solve these problems, we are poised to make unique contributions to the practice of medicine here on Earth.*

*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. The International Space Station will broaden this activity. NASA provides knowledge, policies, and technical support to facilitate industry investment in space research.*

## Strategic Goals

1. *Expand the space frontier*
2. *Expand scientific knowledge*
3. *Enable and establish a permanent and productive human presence in Earth orbit*
4. *Expand the commercial development of space*
5. *Share the experience and discovery of human space flight*

FY 2001 Budget in Millions
$362




## FY 2001 Performance

*The Biological and Physical Research Enterprise created in FY 2001, achieved 90 percent of its FY 2001 annual performance goals in the area of biological and physical research.*

# Human Exploration and Development of Space

*The mission of NASA's human exploration and space effort is to open the space frontier by exploring, using, and enabling the development of space and to expand the human experience into the far reaches of space.*

*In exploring space, NASA brings people and machines together to overcome challenges of distance, time, and environment. Robotic science missions survey and characterize other bodies as precursors to eventual human missions. The Space Shuttle and the International Space Station serve as research platforms to pave the way for sustained human presence in space through critical research on human adaptation. These programs also provide opportunities for research with applications on Earth. NASA serves as a catalyst for space development. We will employ breakthrough technologies to revolutionize human space flight.*

*NASA pursues the answers to a myriad of research and engineering questions that must be answered as we learn to live and work in space. The human exploration and development effort plays an important role in pursuing answers to the following questions:*

- *What is the fundamental role of gravity and cosmic radiation in vital biological, physical, and chemical systems in space, on other planetary bodies, and on Earth?*
- *How do we apply this fundamental knowledge to the establishment of permanent human presence in space to improve life on Earth?*

*Human exploration and development of space also plays an important role working with NASA's space science effort to answer other fundamental questions such as:*

- *Does life exist elsewhere than on our planet?*

*In the long term, these technologies will enable affordable, extended exploration of the solar system and operations in space. Key technologies will include the resupply or recycling of all consumables, including food, air, water, and propellants that are already in place. Moreover, advanced screening and health care delivery, as well as effective control over the physiological effects of transitions among a variety of gravity and radiation environments through many different durations, will be developed. Major Space Shuttle improvements are under consideration. Revolutionary transportation concepts for accommodating humans, including travel to distant destinations, will also be developed.*

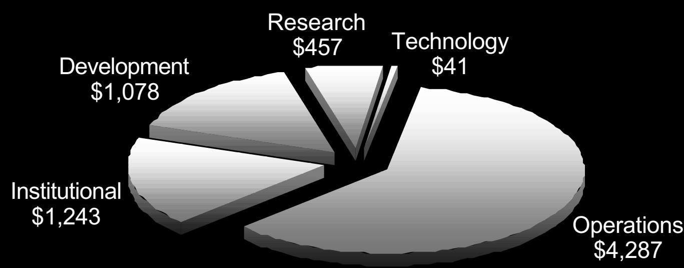
**NASA continues work on the International Space Station, the most powerful and complex spacecraft ever built**

20 February 2001. In the grasp of the Shuttle's remote manipulator system robot arm, the Destiny laboratory is moved from its stowage position in the cargo bay of the Space Shuttle Atlantis. Destiny was the first science laboratory delivered to the International Space Station.

## Strategic Goals

1. Expand the space frontier
2. Enable and establish a permanent and productive human presence in Earth orbit
3. Expand commercial development of space
4. Share the experience and discovery of human space flight

FY 2001 Budget in Milliions
$7,106




## FY 2001 Performance

*Overall, NASA achieved 75 percent of its FY 2001 annual performance goals in the area of human exploration and development of space. This is a substantial improvement over FY 2000.*

*FY 2001 human space flight programs made substantial strides in technological progress, and produced remarkable results. However, it was necessary to redirect some advanced areas in order to address the cost and program management needs of the International Space Station. NASA anticipates continued progress in the development of a permanent human presence in space and expansion of the space frontier.*

**NASA aerospace technology develops systems for future air travel**

NASA Ames Research Center's FutureFlight Central is the world's premier technical design studio for 21st Century airport operations and planning. It is a full-scale airport operations simulator that has the look and feel of an actual air traffic control tower cab.The FutureFlight Central Cab shown here has full-scale consoles and functionally accurate computer displays that replicate controller position-specific equipment.

# Aerospace Technology

*Aerospace technology strives to radically improve air travel on Earth and develop more affordable, reliable, and safe access to space.*

*Aerospace technology plays a key role in maintaining a safe and efficient national aviation system, enabling an affordable, reliable space transportation system, and developing basic technologies for a broad range of space missions. Research and development programs contribute to NASA's science and exploration missions, national security, economic growth, and the long-term competitiveness of American aerospace companies.*

*A modern air and space transportation system is fundamental to our national economy, quality of life, and security of the United States. For 75 years, a strong base for aerospace technology research and development has provided enormous contributions to this system, contributions that have fostered the economic growth of our Nation and provided unprecedented mobility for U.S. citizens.*

*Although major technical advances have made our Nation's air and space transportation system the largest and best of its kind, the future holds critical challenges to its continued growth and performance. Because the U.S. air and space transportation system serves both critical national security needs and the public good, ensuring the continued health and preeminence of that system is a key issue for the future of the Nation.*

*In order to develop the aerospace systems of the future, revolutionary approaches to system design and technology development will be necessary. 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.*

*Although NASA technology benefits the aerospace industry directly, the creative application of NASA's advanced technology to disparate design and development challenges has made numerous contributions to other areas, such as the environment, surface transportation, and medicine.*

## Strategic Goals

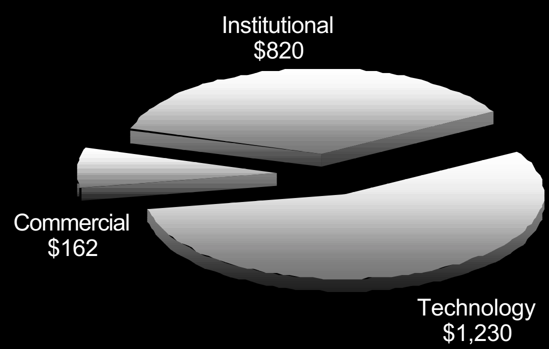
1. *Develop an environmentally friendly global air transportation system for the next century of unquestioned safety that improves the Nation's mobility*

2. *Revolutionize air travel and the way in which air and space vehicles are designed, built, and operated*

3. *Achieve the full potential of space for all human endeavor through affordable space transportation*

4. *Enable, and as appropriate, provide on a national basis, world-class aerospace research and development services, including facilities and expertise*

FY 2001 Budget in Millions
$2,213




## FY 2001 Performance

*Overall, 46 percent of NASA's aerospace technology annual performance goals were achieved in FY 2001. This level of performance represents a slight decrease from FY 2000.*

# NASA's Mission Is Supported Through Four Crosscutting Processes

- *Manage Strategically*
- *Generate Knowledge*
- *Communicate Knowledge*
- *Provide Aerospace Products and Capabilities*

**NASA operates in the Space Station and telescience era**

In the Space Station era, investigators work in telescience centers at their universities or companies. They can send commands to their experiments or talk with the crew through NASA's Payload Operations Center in Huntsville, Alabama. Here, NASA-funded researchers monitor their biotechnology experiment from a telescience center at the University of Colorado in Boulder.

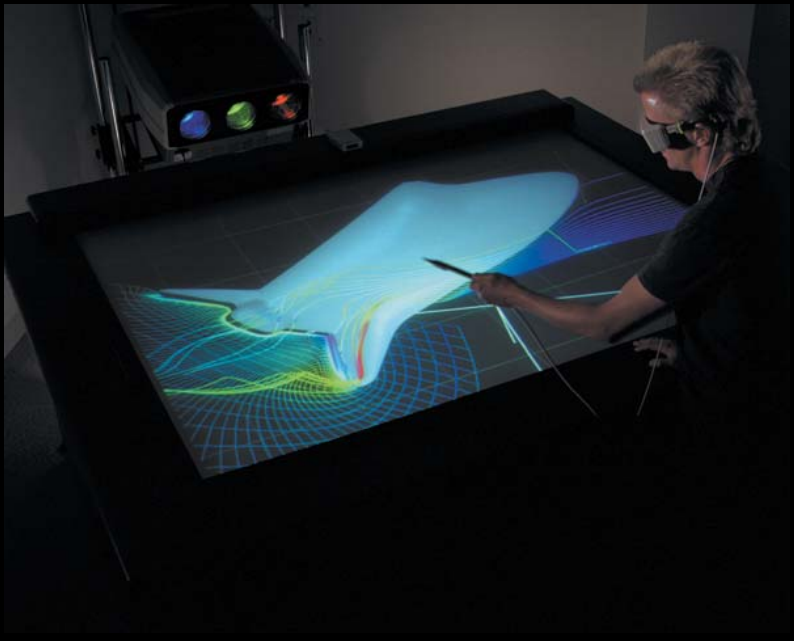
# Manage Strategically

*This is the process by which the Agency meets its responsibilities safely and effectively, as it allocates its resources to support NASA's strategic, implementation, and performance plans.*

*As a Federal agency, NASA places a high priority on managing public funds and tax-supported resources efficiently, effectively, and safely. Identifying Manage Strategically as an Agency crosscutting process reflects NASA's commitment to this public trust. Managing strategically is the foundation of NASA's capacity for visible research and exploration programs that the public associates with the Agency. What must be apparent in the process, however, is evidence that NASA is steering the Agency strategically toward its short- and long-term goals. Therefore, the purpose of this process is to measure NASA's effectiveness in managing health and safety issues, contractual obligations, fiscal matters, facilities revitalization, environmental impact, employee recruitment and retention, and information and systems security to ensure that NASA's management decisions are sound, well-reasoned, and always made to serve the public trust.*

**NASA needs outstanding information technology personnel and an exceptional information technology infrastructure**

As a premier research and development organization, NASA needs both the human capital and the information infrastructure that will take it to the furthest reaches of space. Here, a NASA Ames employee uses Distributed Collaborative Virtual Wind Tunnel Software developed by NASA to enable interactive, three-dimensional visualization of vector and scalar datasets such as those generated by aerodynamic simulations. He is using active stereo glasses and a workbench as an interactive display unit.



## *Strategic Goal*

*The goal of this process is to ensure that the Agency carries out its responsibilities effectively, efficiently, and safely through sound management decisions and practices.*

## *FY 2001 Performance*

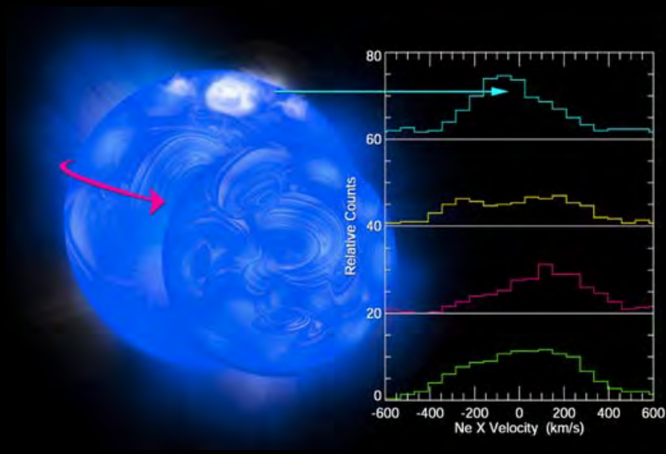
*Overall, NASA achieved 75 percent of the annual performance goals associated with this process. This represents a decrease in performance from FY 2000.*

*In FY 2001, NASA was successful in achieving annual performance goals associated with contract management, facility management system and human resource revitalization, and information technology infrastructure improvement. NASA is currently engaged in a significant effort to further enhance Agency management consistent with the President's Management Agenda.*

**How would our Sun behave differently if it had a closely orbiting twin?**

While astronomers don't know the exact answer, NASA's Chandra X-ray Observatory has observed an intriguing star system that is beginning to provide important clues. These stars, part of the system known as 44i Bootis, orbit so quickly that they pass in front of one another every 3 hours. The alignment of the two stars moving around each other enables us to learn more about magnetic fields and outer atmospheres in stars like our Sun.

This artist's conception depicts the two closely orbiting stars of 44i Bootis. The red arrow in the illustration indicates the direction that the stars are orbiting. The plots to the right show Chandra data on X-ray emission from Neon ions. The four panels show the shift in wavelength at which the Neon X-ray emission peaks as the stars orbit one another.




# Generate Knowledge

*This is the process by which NASA acquires new scientific and technological knowledge from exploring Earth, the solar system, and the universe; and from researching biological, chemical, and physical processes in the space environment; and from aeronautics and astronautics activities. This process seeks to ensure that the science and technology funded by NASA is of the highest caliber. Customers benefiting from this research include scientists, engineers, technologists, natural resource managers, policymakers, educators, and the general public. Generating knowledge is central to NASA's mission and is the primary means through which we seek answers to our fundamental questions.*

*The Generate Knowledge process allows the Agency to maintain the quality and relevance of its research programs. Generate Knowledge is significant in that it ensures that the funding of NASA's programs is consistent with the mission of the Agency and only the most sound research is funded. NASA acquires advice from diverse communities to ensure that its research programs are at the forefront of the various scientific disciplines funded by the Agency. This advice is gathered by two principal methods: through the Enterprises' Federal Advisory Committee Act-chartered committees and through external reviews by organizations such as the National Research Council. The recommendations of these panels are used to help plan and set research priorities, which are documented in the Enterprises' strategic plans. These plans are updated periodically to ensure that our programs' research directions follow the latest scientific priorities. The directions outlined in the strategic plans, in turn, guide the solicitation and peer review of research proposals. Only the most meritorious peer-reviewed research is selected and funded. In aggregate, these funded grants form the core of NASA's research programs. Our research is scientifically validated when it is published in refereed journals and when it is subsequently cited by other researchers; for this is how the scientific community signals which discoveries are both relevant and rigorous in the continuous search for knowledge. NASA ensures that the public and other non-scientific communities are kept abreast of the latest discoveries by maintaining web sites and data archives. It must be noted that the process does not include research of a proprietary industrial nature or research for which conduct or dissemination is limited for reasons of national security.*

## *Strategic Goal*

*Extend the boundaries of knowledge of science and engineering, to capture new knowledge in useful and transferable media, and to share new knowledge with customers.*

## *FY 2001 Performance*

*In FY 2001, 86 percent of the annual performance goals were achieved. This level of performance represents a slight increase from FY 2000.*

# Communicate Knowledge

*NASA uses this process to increase understanding of science and technology, advance its broad application, and inspire achievement and innovation. This process also ensures that the knowledge derived from NASA's research and development programs is presented and transmitted to meet the specific needs and interests of each of the Agency's constituency groups.*

*NASA offers the public numerous opportunities to share the discoveries from NASA missions and programs through portable exhibits at events throughout the country. The NASA Fine Arts Program offers the artists' interpretation of the inspiration from NASA endeavors to viewers in many cities where the art is displayed. Live satellite interviews with astronauts and NASA officials provide timely feedback to the public as missions progress and draw to completion. Research and technology resulting from NASA efforts are readily available through on-line databases for individuals or companies to use for improving the quality of their lives in ways only limited by their imagination. Our education office works closely with teachers and students across the country to excite them with new findings in the universe of knowledge and develop new curriculum to engage youth in the pursuit of scientific and technical fields. NASA is in the business of expanding human access to knowledge.*


**NASA communicates our vision of the future**

The Starship 2040 exhibit is housed in a 48-foot tractor-trailer rig, permitting it to travel around the Nation, demonstrating NASA's vision of what commercial space flight might be like 40 years from now.

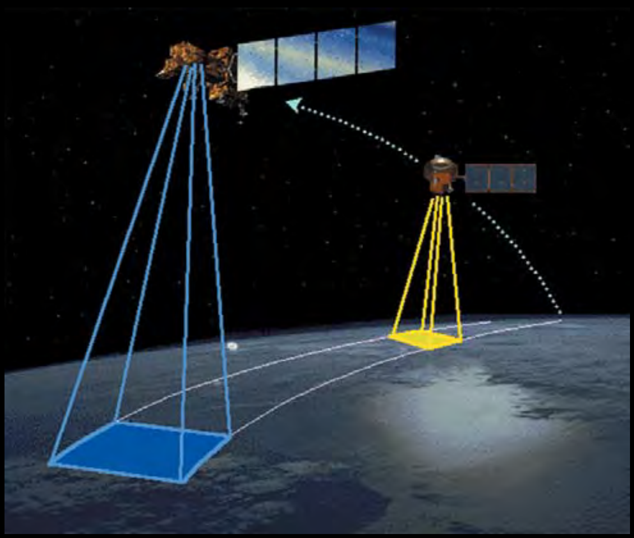
## *Strategic Goal*

*Ensure that information derived from NASA's research efforts is distributed in a useful, timely, and reliable manner.*

## *FY 2001 Performance*

*Overall NASA activities achieved 100 percent of the annual performance goals set for this year. This level of performance represents a marked improvement in performance over FY 2000.*

# Provide Aerospace Products and Capabilities



**NASA demonstrates formation flying capability**

The Earth Observing 1 spacecraft is demonstrating seven revolutionary technologies, including enhanced formation flying. This technology will enable a large number of spacecraft to be managed with a minimum of ground support. The result will be a group of spacecraft with the ability to detect errors and cooperatively agree on the appropriate maneuver to maintain its desired positions and orientations. Creating a virtual super-satellite for concurrent data collection, enhanced formation flying increases science data collection capability and adds considerable flexibility to future Earth and space science missions.

*This process is the means by which the strategic enterprises deliver systems (aeronautics, space, and ground), technologies, data, and operational services to NASA customers so they can conduct research, explore and develop space, and improve life on Earth. The Agency uses the process to answer the following fundamental questions:*

- *What cutting-edge technologies, processes, techniques, and engineering capabilities must we develop to enable our research agenda in the most productive, economical, and timely manner?*
- *How can we most effectively execute those developments in order to transfer the knowledge we gain from our research and discoveries to commercial ventures in the air, in space, and on Earth?*

*The process strives to determine how we can most effectively and efficiently provide aerospace products and capabilities to our customers. Specific objectives include:*

- *Enhance program safety and mission success in the timely delivery of products and operational services within reasonable resource estimates;*
- *Enable technology planning, development, and integration driven by strategic enterprise customer needs;*
- *Facilitate technology insertion and transfer, and utilize commercial partnerships in research and development to the maximum extent practicable;*
- *Improve NASA's engineering capability, to remain as a premier engineering research and development organization; and*
- *Capture engineering and technological best practices and process knowledge to continuously improve NASA's program/project management.*

## *Strategic Goal*

*Enable NASA's Strategic Enterprises and their Centers to deliver products and services more effectively and efficiently.*

## *FY 2001 Performance*

*Overall, FY 2001 annual performance goal achievement was 67 percent. This represents a slight improvement in performance over FY 2000.*

*Exceptional performance was documented for annual performance goals aimed at keeping spacecraft and ground facility downtime to a minimum and establishing commercial partnerships. Annual performance goals were also achieved in the areas of software independent verification and validation and emerging technology investment. Challenges were encountered in meeting annual performance goals related to program and project management: meeting cost and schedule commitments, and documenting best practices and lessons learned so future efforts can benefit from both the achievements and challenges of the past.*

# Report Organization

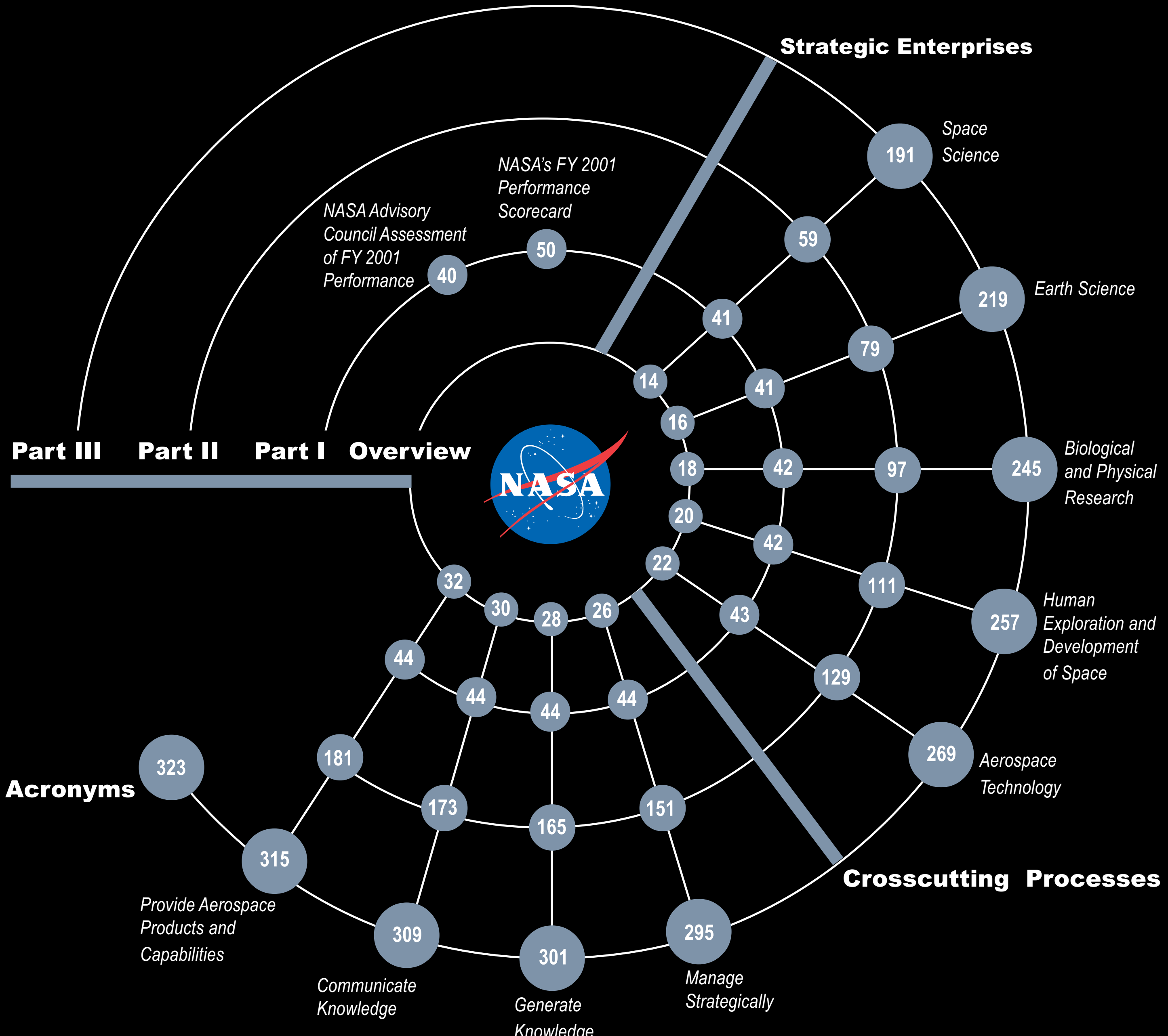
*NASA's FY 2001 Performance Report began with this Overview that addresses the public benefits of America's investment in NASA's mission, as well as the means through which NASA's mission is accomplished—the Strategic Enterprises, their strategic goals and the nature of NASA's work.*

*The Report is then divided into the following three parts:*

- *Part I: A summary that includes an independent performance assessment, internal and external reviews, a description of NASA's performance assessment process, and a summary scorecard of FY 2001 performance.*
- *Part II: A discussion of the performance evaluation of each Strategic Enterprise and Crosscutting Process that includes achievements, challenges, annual performance goal assessments, and 3-year performance trends for each strategic goal.*
- *Part III: Detailed supporting material for each Strategic Enterprise and Crosscutting Process performance evaluation as discussed in Part II to include data sources, data voids, results, performance assessments, and action plans for annual performance goals that were not achieved but significant progress was made in FY 2001.*

*The following graphical guide to the contents of the report shows these four parts as concentric circles of ever increasing detail. Tracing information for a specific NASA Enterprise or Crosscutting Process is facilitated through nodes in the circles that contain page numbers.*

# Roadmap


Strategic Enterprises
Space Science
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# Part I

## Performance Summary

# Independent Evaluations

NASA performance assessment data presented in this report were subjected to two forms of independent assessment, one by NASA's Office of Inspector General and one by the NASA Advisory Council.

**Office of Inspector General**

NASA's Office of Inspector General is an independent audit and investigative unit created under Public Law 95-452, known as the Inspector General Act of 1978. The Office of Inspector General conducted an audit of NASA's FY 2001 performance assessment findings. The report, entitled "Audit of Validation and Verification of Selected NASA Performance Data Related to GRPA," will be completed April 2002 and posted on the NASA web page http://www.hq.nasa.gov/office/oig/hq/reports.html.

**NASA Advisory Council**

The NASA Advisory Council is an independent unit established to provide advice and counsel on NASA programs and issues. The following eight standing advisory committees report to the NASA Advisory Council:

- Space Flight
- Aerospace Technology
- Earth System Science and Applications
- Biological and Physical Research
- Minority Business Resource
- Space Science
- Technology and Commercialization
- Planetary Protection Advisory Committee

The NASA Advisory Council and its committees operate under the Federal Advisory Committee Act. Accordingly, the meetings are usually open to the public and announced in the Federal Register. NASA Advisory Council records are available to the public as specified in the Freedom of Information Act. Additional information on the Council is available at http://www.hq.nasa.gov/office/codez/new/poladvisor.html.

The NASA Advisory Council independent review of NASA's FY 2001 performance assessment results is presented on the following pages.

# NASA Advisory Council

National Aeronautics and Space Administration
Washington, DC 20546



January 22, 2002

Mr. Sean O'Keefe
Administrator
National Aeronautics and
Space Administration
Washington, DC 20546

Dear Mr. O'Keefe:

The NASA Advisory Council appreciates the opportunity to provide an independent, qualitative review of the Agency's annual performance as a part of NASA's submission to Congress for the Government Performance and Results Act. At its very substantive meeting at NASA Headquarters on December 7, 2001, the NASA Advisory Council reviewed NASA's performance relative to its FY 2001 Revised Final Performance Plan.

Based on its review and the input of its committees, the Council finds that NASA has achieved the established strategic goals and objectives for FY 2001 in many, but not all areas. In particular, the Agency needs to restructure the International Space Station program to resolve the deficiencies in management and financial control identified by the NASA Advisory Council. Furthermore, the NASA Advisory Council urges that the Agency clarify the priorities for International Space Station utilization and then more firmly communicate the benefits of the International Space Station to its stakeholders. While the Agency did under-perform in some other areas, most of these were management decisions forced by schedule slips, unproven technology, and/or cost increases. Given the well known difficulty of measuring annual progress in scientific research and technology development, the Agency's assessment of its performance in these areas reflects reasonably well what it has achieved and where it needs to improve.

The NASA Advisory Council has seen significant improvement in how NASA conducts the Government Performance and Results Act process. Nonetheless, the Agency should continue to refine its metrics to ensure that they are clear, measurable, and most importantly, significant. The performance plans and reports, should they be further improved, could become a useful communication tool.

The NASA Advisory Council understands the value of the Government Performance and Results Act process and looks forward to its continued participation in helping NASA's management to allocate its appropriated resources in the ways most effective to meet its strategic goals.

Sincerely,

Charles F. Kennel

Charles F. Kennel
Chairman
NASA Advisory Council

Enclosure

## NASA Advisory Council Assessment of FY 2001 Performance

The role of the NASA Advisory Council in the [Government and Performance Results Act] process is to provide an external, independent evaluation of NASA's performance against the FY 2001 Revised Final Performance Plan developed by the NASA Enterprises and [Crosscutting] Process stewards. The following comments are specific to each evaluation area:

### Space Science

The Space Science Enterprise achieved a majority of their performance metrics. Success was achieved in meeting the goals, charting the evolution of the universe from origins to destiny, and understanding its galaxies, stars, and life. The performance of operating missions was exceptional during FY 2001, with Hubble Space Telescope, Chandra X-Ray Observatory, Solar & Heliosphere Observatory, Submillimeter Wave Astronomy Satellite, and Far Ultraviolet Spectroscopic Explorer yielding particularly valuable science results. The Mars Global Surveyor continued its unprecedented success. Additionally, Microwave Anisotropy Probe, Mars Odyssey, and Genesis missions were successfully launched. The Keck Project successfully linked the world's two largest telescopes to create a single optical instrument powerful enough to pinpoint planets orbiting other stars. Furthermore, the Enterprise increased its education and public outreach activities over FY 2000 levels.

The development of new technologies needed to carry out innovative and less costly mission and research concepts saw marginal results.

In summary, FY 2001 was a year of solid achievement for the Space Science Enterprise.

### Earth Science

The Earth Science Enterprise had many positive achievements in FY 2001 as reflected by their attainment of the majority of their performance metrics. One spacecraft (Earth Observing-1) was successfully developed and launched. The scientific understanding of land cover and land use change, climate change, atmospheric ozone, and natural hazards continues to advance. More data and information were archived and distributed to a greater number of users than targeted. Approximately 15 million data products were distributed to 2.3 million users in FY 2001. The median delivery time was less than 1 day and the error free rate was over 99 percent. User surveys indicated satisfaction with the data and information service. The NASA Advisory Council commends the Enterprise's accomplishment in education and student research program goals.

On the negative side, the launches of Jason-1, Earth Observing System-Aqua, Vegetation Canopy Lidar, and Triana were delayed for various reasons, and an Enterprise satellite was lost in a commercial launch failure.

The Enterprise was very effective at using its science plan to guide the creation of its performance goals, and applied "lessons learned" effectively. On the other hand, it has proven difficult to estimate user satisfaction with NASA's Earth science data products. To address this, a redesigned user survey system should be developed in FY 2002.

While the Enterprise's small scientific grants program is funded at a significant level, it is difficult to measure the success of this, or any other research and technology development program, using annual performance metrics. The ultimate measures are the scientific progress that is enabled by NASA, the excitement of its scientific quest, and the human significance of its findings. The [NASA Advisory Council] urges that the Enterprise communicate ever more actively the excitement and successes of its scientific findings to the public. One way would be to develop and relate NASA's role in the history of key discoveries.

**Biological and Physical Research**

The Biological and Physical Research Enterprise achieved a majority of their performance metrics. The Enterprise initiated a program of research on the [International Space Station] to take advantage of available resources during the construction phase, released three research announcements, and strengthened its research investigator community. A new memorandum of understanding with the U.S. Department of Agriculture was established to conduct a joint research solicitation with the National Cancer Institute, and work continued under 18 other agreements with the National Institutes of Health. Commercial partnerships are expanding at well above the planned rate (20+ new partnerships versus a plan of 10). The Enterprise also made progress in countermeasures for the negative effects of the space environment. The Enterprise met its goals in education and public outreach.

In FY 2001, the Enterprise began major efforts to restructure the [International Space Station] program research. These efforts respond to substantial reductions in available budgets for research equipment (facilities) as well as potential reductions in available resources for research, especially crew time for research.

The development of the Mars Surveyor Program is progressing smoothly, the only disappointment being the cancellation of the lander portion of the mission.

**Human Exploration and Development of Space**

The [Human Exploration and Development of Space] Enterprise achieved most of their performance metrics. The Enterprise also had a perfect record of human space flight safety in FY 2001 during seven Space Shuttle missions and with the achievement of permanent human presence on the International Space Station.

Flight safety will always be the top priority. For this reason, the [NASA Advisory Council] endorses a viable Shuttle Safety Upgrades program. A concern is that many planned safety upgrades have not proven to be technically feasible, timely, and/or affordable within the prescribed budget. All Shuttle missions achieved 100 percent mission success with an average of 4.57 anomalies per mission (against a goal of no more than 8.0).

The continued assembly and operation of the [International Space Station] has been a technological marvel. Cost and management issues relating to the [International Space Station] program presently overshadow its technical successes. Managing the program to annual budget caps rather than total budget cost, together with inadequate cost management tools, led to significant cost growth. As one sign of the deficiency, there are no [International Space Station] performance metrics that track and report cost and schedule performance in the Agency Performance Plan.

The performance goal, expanding the space frontier, had mixed results. The NASA Exploration Team for science-driven and technology enabled capabilities continued to define potential human/robotic exploration architectures and technologies. However, due to [International Space Station] funding concerns, the [Human Exploration and Development of Space] Technology and Commercialization Initiative to implement technology research was discontinued.

Although the Enterprise formally met its performance goal, sharing the experience and benefits of discovery of human space flight to benefit all people, [the NASA Advisory Council] notes that significant improvement will be needed. The [NASA Advisory Council] believes that failure to communicate the reasons for, and benefits of, human space flight may become the greatest long-term limiter on the future of the [International Space Station].

## Aerospace Technology

The Aerospace Technology Enterprise did not achieve a majority of their performance metrics. As an enabler, the Enterprise depends on others to utilize its technology. In its user surveys, the Enterprise received high marks for its efforts in transferring new technologies and processes to industry.

In the area of global aviation, significant progress was made in safety, environmental compatibility, and capacity. Significant FY 2001 efforts included improving safety with a flight demonstration of a prototype synthetic vision system; transfer of low [nitrogen oxide] combustor (50 percent emissions reduction) technology to industry; completion of large-scale noise reduction technology; and development of Collaborative Arrival Planner tool and Direct-To tools. Slight schedule delays to evaluate the system benefits of the technical achievements have occurred.

The strategic goal, revolutionizing air travel and the way in which air and space vehicles are designed, built, and operated, has proven difficult to achieve. The [NASA Advisory Council] notes that pursuit of "revolutionary" goals will result in a range of successes and failures. The Enterprise saw success with its successful completion of [Advanced General Aviation Transport Experiment] technology tests and with the absolute altitude record for non-rocket powered aircraft with its Helios aircraft. The Enterprise experienced failure with the X-43's first flight and with the suspension and restructuring of its [Revolutionary Concepts] program.

The strategic goal, achieving the full potential of space for all human endeavor through affordable space transportation, had mixed results. The Space Launch Initiative awarded 22 contracts in FY 2001. Additionally, the X-33 program had a successful Linear Aerospike Dual Engine test firing. The terminations of the X-33 and X-34 programs due to technical and resulting budget issues are the most significant disappointments. The challenge for the Enterprise is to develop methodologies and tools to manage the [Space Launch Initiative] technology investments. Future performance metrics must drive the [Space Launch Initiative] investments to accomplish incremental advancements in technology development with the associated reduction of cost risks, to enable a mid-decade decision on a new launch system.

**Agency Crosscutting Processes**

Generally speaking, aside from the management and cost control issues associated with the [International Space Station] program, the Agency performed well in meeting its goal to Manage Strategically. NASA increased the safety of its infrastructure and workforce; increased the percentage of contract dollars obligated to performance based contracts and the percentage of dollars awarded to small disadvantaged businesses; increased representation of minorities and women; improved [information technology] infrastructure service and customer ratings while cutting costs; and enhanced [information technology] security. Metrics were not met because the Agency did not award 100 percent of the construction contracts planned to improve safety requirements in all critical facilities. The Agency also fell short of achieving its workforce diversity goals.

The Agency goal to Provide Aerospace Products and Capabilities had mixed results. The Agency must do a better job of cost estimating. To address this, the Agency is initiating a requirement for earlier and more rigorous Life Cycle Cost estimating. The Agency also needs to better acknowledge where the risks and technology dependencies are and accommodate potential cost variances. Lastly, the Agency needs to do a better job of articulating the variances.

It was acknowledged that gauging the success of the overall Agency in meeting the goal to Generate Knowledge is difficult to measure, primarily because the successes of the Agency are reported by the individual Enterprises. The [NASA Advisory Council] observed that the metrics in the common process are narrowly focused, and don't account for the "communicating" that goes on in the Enterprises. The [NASA Advisory Council] notes that most of the current metrics are output metrics that do not clearly convey the impacts of the science and education programs.

Although NASA's performance metrics provide information on how the Agency provides knowledge to the public, they fail to capture the excitement of its research programs. The [NASA Advisory Council] urges that the Agency of course collect quantitative statistics, but also present a few top scientific and technological accomplishments of the year and trace them back to their beginnings. This would demonstrate how these efforts progress from initial funding of research to a significant result.

NASA is doing a good job of presenting itself to the public, but still should do better. The Agency continues to build its ties with the educational community through space-focused curriculum for elementary through high school students, and research opportunities and funding at the university level. However, the metrics do not adequately reflect the larger issue of the Agency's obligation to Communicate Knowledge of its efforts and results to the taxpayer.

The [NASA Advisory Council] notes that although NASA is actively involved in many activities related to education, communication, and public outreach, NASA's overall program is not well enough conveyed to the public as a cohesive, integrated effort with broad public significance.

# NASA's Performance Assessment Process

NASA's basic unit of performance measurement is the annual performance goal. NASA uses indicators defined in the Performance Plan to arrive at annual performance goal assessments. These assessments are, in turn, combined to determine how well each area of endeavor (Enterprise or Crosscutting Process) performed. Considered collectively, annual performance goals demonstrate how the Agency as a whole performed in FY 2001.

## Assessment Code Assignment

NASA assigns a color-coded performance assessment (blue, green, yellow, red, or N/A) to each annual performance goal once all data for the fiscal year have been collected and analyzed. Definitions of the performance assessment codes are presented in the following table.

| | Performance Assessment Color Codes |
|---|---|
| ● (blue) | Significantly exceeded annual performance goal |
| ● (green) | Achieved annual performance goal |
| ● (yellow) | Failed to achieve annual performance goal, progress was significant, and achievement is anticipated within the next fiscal year |
| ● (red) | Failed to achieve annual performance goal, completion within the next fiscal year is not anticipated, and target may be unfeasible or unachievable |
| N/A | No longer applicable |

## Internal and External Evaluations

NASA uses a variety of methods to measure programmatic progress from executive-level reviews to resource analyses done at the project level by Center personnel. Major programs are routinely reviewed on a quarterly basis by the Agency's Program Management Council at NASA Headquarters. These reviews track cost, schedule, and technical status, and highlight items for executive-level consideration. NASA's various Advisory Committees are briefed regularly by the five Strategic Enterprises on the progress of their programs. These reviews allow the expert community, external to NASA, input on and validation of the Agency's scientific and technical efforts. Center managers receive briefings on the activities conducted at their Centers, enabling them to monitor resource utilization at the management level of the organization. Project managers have several methods that provide them with insight into the performance and status of their programs, including briefings by civil servant and contractor resource analysts. Such program and project evaluations examine cost, schedule, and technical performance at the level of granularity that include measurement of performance against technical specifications and tolerances required for effective day-to-day program management. All of these reviews are important to the efficient and effective execution of NASA's many science and technology efforts, and they provide overlapping and complementary coverage to managers across the Agency.

| NASA Program Evaluations | | |
|---|---|---|
| **Evaluation** | **Scope** | **Year Completed** |
| | **AGENCY-WIDE** | |
| President's Executive Scorecard | Focus on five main areas targeted for evaluation and improvement: human capital, competitive sourcing, e-government, financial management, integration of budget and performance | Ongoing |
| | **SPACE SCIENCE** | |
| Senior Review | Evaluation of mission progress in operations and data analysis programs by a panel of peers external to the Agency that is conducted at the division level on a two- to three-year cycle | August 2001(Sun-Earth Connection Division) |
| Solar System Exploration Decadal Survey | Survey conducted by the National Research Council used to set science priorities | Late FY 2002 |
| Assessment of Mars Science and Mission Priorities | Review of scientific priorities for the exploration of Mars conducted by the National Research Council | Mid FY 2002 |
| Education and Public Outreach Program Evaluation | Comprehensive evaluation conducted by the Program Evaluation and Research Group, Lesley University, Cambridge, Massachusetts | FY 2002 |
| Space Science Advisory Committee | Comprehensive Space Science Enterprise review of Education/Outreach Program | FY 2003 |
| | **EARTH SCIENCE** | |
| National Research Council Space Studies Board and Board on Earth Sciences and Resources | Evaluation of the availability and usefulness of space mission data | Ongoing |
| Earth Observing System Independent Annual Review | Evaluation of Earth Observing missions by the Langley Research Center | Completed 12/00 |
| Earth System Science and Applications Advisory Committee | Reviews of all missions, programs and plans by university, industry and other Federal agency leaders | Semi-annual |
| Earth Science Data and Information Systems and Services Review | Review of new data and information systems and services documented during FY 2001 | Biannual: last completed 10/1/01 |
| | **BIOLOGICAL AND PHYSICAL RESEARCH** | |
| Space Station Research Review | National Research Council Task Group on International Space Station Research review of scientific community's readiness for conducting Space Station research and steps for improving efficiency on Space Station | 2002 and 2003 |
| Space Station Cost and Management Evaluation Task Force | Advisory Committee reporting the NASA Advisory Committee on Space Station management including recommendations on priorities for research | 2002 |
| Research Maximization and Prioritization Task force report | Review and recommend priorities for Space Station research | 2002 |
| Physical Science Research Review | National Research Council committee review of the Enterprise physical science research | 2003 |
| A Strategy for Research in Space Biology and Medicine in the New Century | National Research Council committee review of the Enterprise used to establish research direction | 1999 |
| Performance Review of Commercial Space Centers | Rolling review of the Enterprise Commercial Space Centers to assess performance | 2002, 2003, 2004 |
| Microgravity Research in Support of Technologies for the Human Exploration and Development of Space and Planetary Bodies | National Research Council committee review of high priority physical science research to support human exploration of space | 2000 |

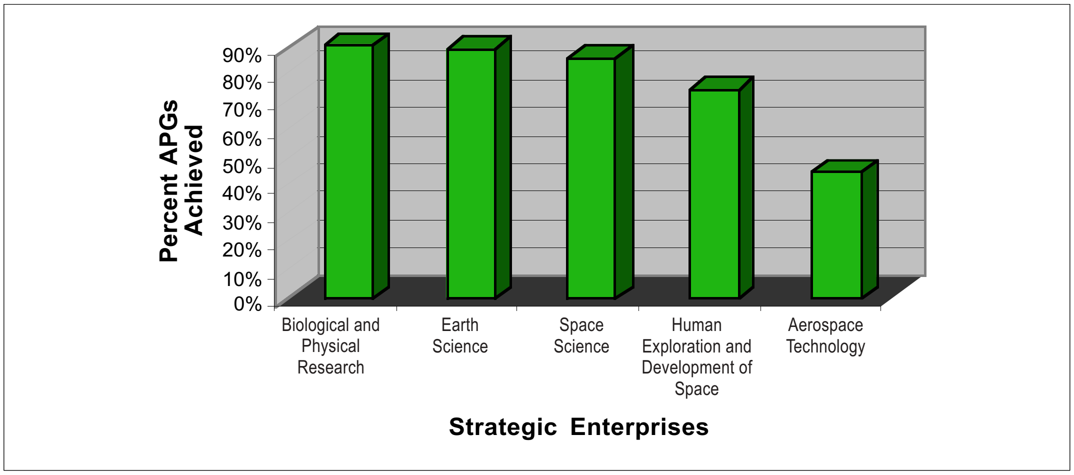
| NASA Program Evaluations | | |
|---|---|---|
| **Evaluation** | **Scope** | **Year Completed** |
| | **HUMAN EXPLORATION AND DEVELOPMENT OF SPACE** | |
| | **Schedule of Advanced Program Evaluations** | |
| National Research Council assessment of NASA Exploration Team and Technology for Human/ Robotic Exploration and Development of Space/ Technology and Commercialization Initiative | This external peer review was initiated at the request of the Human Exploration and Development of Space Advanced Programs office. It was intended to critique and advise on the merits of the plans and priorities of planned technology and architecture studies. | Evaluation terminated after the Enterprise Technology and Commercialization Initiative cancellation |
| | **Schedule of Space Shuttle Program Evaluations** | |
| Space Flight Advisory Committee | Review Status of Space Shuttle Safety Upgrades | March 2001 |
| Space Flight Advisory Committee | Assess Readiness of Cockpit Avionics Upgrade for Authority to Proceed | June 2001 |
| Aerospace Safety Advisory Panel | Review of Space Shuttle Program Plan for Orbiter Structural Inspections | August 2001 |
| Inspector General Audit A0104100 | Space Shuttle Safety Upgrades | FY 2002 |
| Inspector General Audit A013800 | Competition in United Space Alliance Subcontracts | FY 2002 |
| | **Schedule of Space Station Program Evaluations** | |
| Space Station Management and Cost Evaluation Task Force - External Review Group | Evaluate the Space Station Program, budget and management challenges. Provide recommendations to improve cost estimating and control. | November 2001 |
| Surveys and Investigation - Staff of the House Appropriations Committee | Examine Space Station cost growth, acquisition oversight, and research accessibility. | Fall 2001 |
| NASA Independent Implementation Review | Review Space Station business practices and High-Risk areas, Including Software, Avionics Obsolescence, Space Station Operations, and Sustaining Engineering | Fall 2001 |
| General Accounting Office Report on Space Station and Shuttle support Cost Limits | Review spending limits associated with Space Station and Shuttle launch costs incurred in connection with assembly of the Space Station. | August 2001 |
| General Accounting Office Space Station Current Costs | Examine causes of Space Station cost growth and management mechanisms that should have alerted NASA Management. | Spring 2002 |
| General Accounting Office Review of Interim Control Module and U.S. Propulsion Module | Identify significant issues in the development, acquisition, cost schedule and implementation of Interim Control Module and Propulsion Module. | Fall 2001 |
| Space Station Propulsion Module Procurement Process | Determine whether NASA considered a competitive procurement process and propriety of modifying an existing contract to add the Propulsion Module. | April 2001 |
| Office of Inspector General Audit of Acquisition of Space Station Propulsion Modules | Determine whether NASA developed a cost-effective acquisition strategy for long-term propulsion capability for Space Station. | May 2001 |
| Office of Inspector General Audit on Restructuring of the Space Station Contract | Determine whether global settlement of the equitable adjustment was appropriately justified and executed; and whether fee structure is appropriate. | Draft August 2001 |
| Office of Inspector General Audit of Space Station Spare Parts Costs | Determine whether NASA is properly acquiring and accounting for Space Station spare parts, and if the value is properly accounted for on the financial statements. | Pre-draft Report August 2001 |

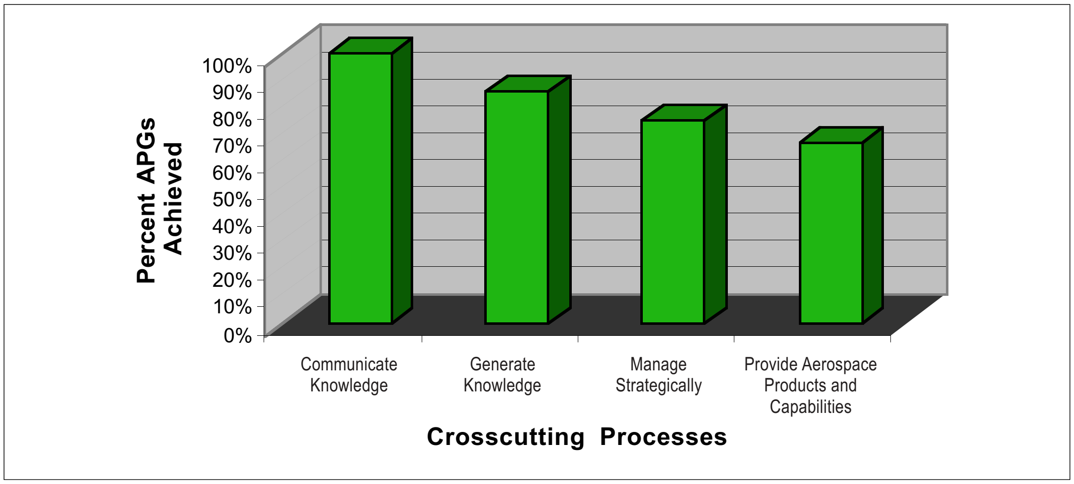
| NASA Program Evaluations | | |
|---|---|---|
| **Evaluation** | **Scope** | **Year Completed** |
| | **HUMAN EXPLORATION AND DEVELOPMENT OF SPACE** *(continued)* | |
| | **Schedule of Space Communications Evaluations** | |
| Deep Space Network 2003-2004 Overload Assessment | Evaluation of anticipated Deep Space Network loading during late 2003 and early 2004 to determine what capacity upgrades will be required to satisfy communications and tracking needs in the Mars viewing area during that period | February 2001 |
| Wide Area Network Benchmark | Assessment of the performance and cost effectiveness of the current Wide Area Network services under Consolidated Space Operations Contract versus similar services and FTS2001 | February 2001 |
| Independent Assessment of the Consolidated Space Operations Contract | Assessment of the performance of the Consolidated Space Operations Contract with respect to the original objectives of the contract | November 2001 |
| | **Schedule of Access to Space Evaluations Scope** | |
| Inspector General Audit A-02-002-00 | Expendable Launch Vehicle Services: Performance Measures and NASA Risk Mitigation Policy | FY 2002 |
| | **AEROSPACE TECHNOLOGY** | |
| Annual Goal Assessment | Independent assessment of progress made toward the achievement of strategic goals | FY 2001 and annually thereafter |
| Office of Aerospace Technology Investment Planning | Assessments needed to develop a targeted investment strategy | FY 2002 (initial assessment) |
| Review of the Pioneer Revolutionary Technology Goal | National Research Council assessment of the scientific and technical quality of the research being conducted in support of the strategic goal | FY 2003 |
| Review of the Revolutionize Aviation Goal | National Research Council assessment of the scientific and technical quality of the research being conducted in support of the strategic goal | FY 2004 |
| National Research Council review of the Advance Space Transportation Goal | National Research Council assessment of the scientific and technical quality of the research conducted in support of the strategic goal | FY 2005 |

# NASA's Performance Assessment Results

### Enterprise and Crosscutting Process Comparisons

NASA achieved 79 percent of its annual performance goals. NASA's achievement of FY 2001 annual performance goals was above 85 percent in the areas of biological and physical research, earth science, and space science and fell below 50 percent only in the area of aerospace technology.




### NASA's FY 2001 Performance Scorecard

The NASA FY 2001 Performance Scorecard shows details of how NASA performed on individual annual performance goals associated with strategic goals. Each tracking number (e.g., 1S1), identifies an annual performance goal.

Further information on a particular annual performance goal as identified by its tracking number can be found in subsequent sections of this report. Part II provides a general discussion of the assessments while Part III provides detailed information on the metrics used to arrive at these assessments.

## NASA FY 2001 Performance Scorecard

| Strategic Goals | Strategic Enterprises |
|---|---|
| | **Space Science** |
| Chart the evolution of the universe from the origins to destiny, and understand its galaxies, stars, and life | 1S2, 1S14, 1S3, 1S4, 1S5, 1S6, 1S7, 1S8, 1S1 |
| Contribute measurably to achieving the science, math, and technology education goals of our Nation | 1S9 |
| Support human exploration through robotic missions | 1S10, 1S11, 1S13 |
| Develop new technologies needed to carry out innovative and less costly mission and research concepts | 1S12 |
| | **Earth Science** |
| Expand scientific knowledge by characterizing the Earth system | 1Y4, 1Y5, 1Y6, 1Y7, 1Y8, 1Y9, 1Y10, 1Y11, 1Y12, 1Y1, 1Y3 |
| Disseminate information about the Earth system | 1Y2 |
| Enable the productive use of Earth science and technology in the public and private sectors | 1Y13, 1Y14, 1Y15, 1Y16, 1Y17, 1Y18 |
| | **Biological and Physical Research** |
| Expand the space frontier | 1H1 N/A |
| Expand scientific knowledge | 1H3, 1H5, 1H4 |
| Enable and establish a permanent and productive human presence in Earth orbit | 1H17, 1H18, 1H31, 1H29 |
| Expand the commercial development of space | 1H22, 1H23 |
| Share the experience and discovery of human space flight | 1H26 |
| | **Human Exploration and Development of Space** |
| Expand the space frontier | 1H2, 1H32, 1H1 N/A |
| Enable and establish a permanent and productive human presence in Earth orbit | 1H7, 1H30, 1H10, 1H12, 1H13, 1H20, 1H21, 1H6, 1H11, 1H14 N/A, 1H15 N/A |
| Share the experience and discovery of human space flight | 1H26 |

| NASA FY 2001 Performance Scorecard | |
|---|---|
| **Strategic Goals** | **Strategic Enterprises** |
| | **Aerospace Technology** |
| Develop an environmentally friendly global air transportation system for the next century of unquestioned safety that improves the Nation's mobility | 1R2 1R4 1R1 1R3 |
| Revolutionize air travel and the way in which air and space vehicles are designed, built, and operated | 1R8 1R7 1R9 |
| Achieve the full potential of space for all human endeavor through affordable space transportation | 1R11 1R10 |
| Enable, and as appropriate provide, on a National basis, world-class aerospace R&D services, including facilities and expertise | 1R12 1R13 |
| **Strategic Goals** | **Crosscutting Processes** |
| | **Manage Strategically** |
| Ensure that the Agency meets its responsibilities safely and effectively, as it allocates its resources to support NASA's strategic, implementation, and performance plans | 1MS2 1MS3 1MS4 1MS1 |
| | **Generate Knowledge** |
| Extend the boundaries of knowledge of science and engineering, to capture new knowledge in useful and transferable media, and to share new knowledge with customers | 1G6 1G7 1G1 1G3 1G4 1G5 1G2 |
| | **Communicate Knowledge** |
| Ensure that information derived from NASA's research efforts is distributed in a useful, timely, and reliable manner | 1CK1 1CK2 1CK3 1CK4 |
| | **Provide Aerospace Products and Capabilities** |
| Enable NASA's strategic enterprises and their Centers to deliver products and services more effectively and efficiently while extending the technology, research, and science benefits broadly to the public and commercial sectors | 1P3 1P5 1P6 1P7 1P1 1P4 |

# Part II

## Performance Discussion

# NASA's Strategic Enterprises

# Space Science

*The primary goal of NASA's space science is to chart the evolution of the universe from origins to destiny, and improve understanding of galaxies, stars, planets, and life. We seek to solve the mysteries of the universe, exploring the solar system, discovering planets around other stars, and searching for life beyond Earth. Other goals include developing innovative technologies to support our space science programs and making them available for other applications that benefit the Nation. Our 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.*

# Space Science

## Strategic Goals

To achieve the Space Science mission, NASA has specified four strategic goals:

1. Chart the evolution of the universe from origins to destiny, and understand its galaxies, stars, and life
2. Contribute measurably to achieving the science, math, and technology education goals of our nation
3. Support human exploration through robotic missions
4. Develop new technologies needed to carry out innovative and less costly mission and research concepts

### Strategic Goal 1. Chart the Evolution of the Universe From Origins to Destiny, and Understand Its Galaxies, Stars, and Life

Understanding our cosmic origins and destiny, how these are linked by cycles of evolution, and how our current universe is structured, is perhaps the most profound and universal objective of humankind. One of the great quests of the last half-millennium since the time of Copernicus is to understand where humanity fits within the Cosmos: How old is the universe? How did it begin and how will it end? What are its primary constituents and how do they interact? NASA has a meaningful, coherent, and bold program of missions that provide new knowledge from which we formulate new questions, bringing us to the next level of scientific inquiry. In FY 2001, NASA produced excellent science results in this area, while at the same time dealing with several issues in missions under development.

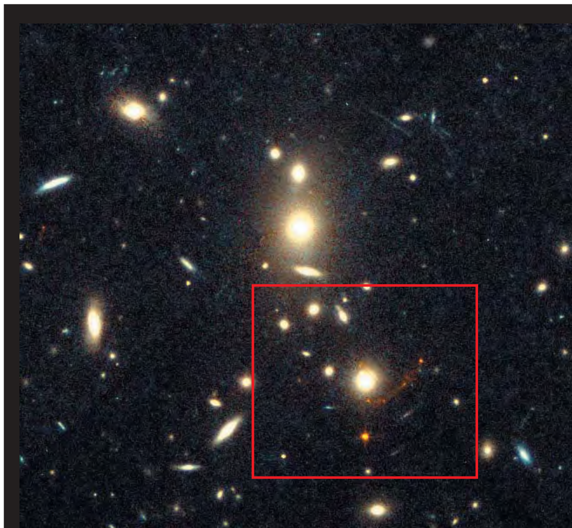
Achievements

NASA faced significant challenges in developing and launching planned missions for this objective. The Galaxy Evolution Explorer launch was delayed until mid-2002 due to problems with detector development and telescope fabrication. In addition, the Cooperative Astrophysics and Technology Satellite, a part of the Student Explorer Demonstration Initiative, was cancelled due to concerns about the lack of progress by the associated university and the resulting risks. However, equally important in this decision was that the scientific question of the origin of gamma-ray bursts has been largely solved, and two other approved missions will better examine the question in light of more recent knowledge.

*Solve the Mysteries of the Universe*

NASA successfully launched the Microwave Anisotropy Probe, an Explorer mission that is measuring the temperature of the cosmic background radiation over the full sky with unprecedented accuracy. This map of the remnant heat from the Big Bang will provide answers to fundamental questions about the origin of our universe. In addition, outstanding progress was made on the Gravity Probe-B mission during the year. Gravity Probe-B is a fundamental physics experiment designed to test Einstein's theory of General Relativity, and is designed to provide crucial evidence in our understanding of how the universe works and evolves.

The performance of operating missions was exceptional during FY 2001. The Submillimeter Wave Astronomy Satellite detected substantial concentrations of water vapor around the aging giant star CW Leonis, located 500 light-years (almost 3,000 trillion miles) from Earth. The observations provide the first evidence that other planetary



**NASA observes the most distant galaxy ever seen**

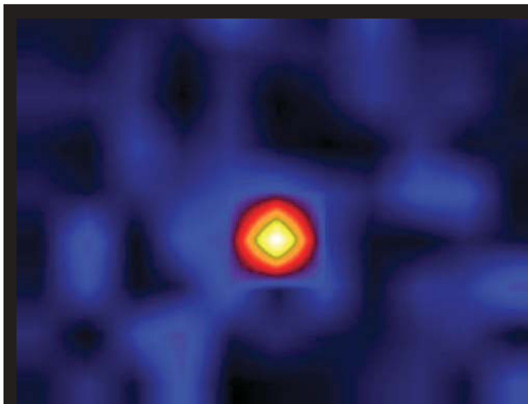
The Hubble Space Telescope image of the galaxy cluster CL1358+62 has uncovered an image of a more distant galaxy located far beyond the cluster. The image appears as a red crescent to the lower right of center (see box). The galaxy's image is brightened, magnified, and smeared into an arc-shape by the gravitational influence of the intervening galaxy cluster, which acts like a gigantic lens.

Spectroscopic observations at the W. M. Keck Observatory in Hawaii show the galaxy is the farthest ever seen. Its light is only reaching us now from a time when the universe was but 7 percent of its current approximate age of 14 billion years. This places the young galaxy as far as 13 billion light-years away. The foreground cluster is 5 billion light-years from us.

A close-up of the image shows why astronomers are excited about this unique opportunity to study the distant galaxy's structure. The stretched-out image reveals tiny knots of vigorous starbirth activity. This provides a first detailed look at the early construction phase of a galaxy undergoing formation.

systems contain water, a molecule that is an essential ingredient for known forms of life, and suggest that other stars may be surrounded by planetary systems similar to our own. The Hubble Space Telescope, in collaboration with the Keck telescope, observed the most distant galaxy ever seen. These observations will have profound implications on our understanding of how and when the first stars and galaxies formed in the universe. Many highly significant observations revealing the nature of black holes were obtained from the Chandra X-ray Observatory in the past year. In FY 2001 alone, the mission's results led to 34 press releases and over 250 newspaper stories. Excellent results were returned from other missions, as well.

Performance in the technology development and supporting research area was mixed. NASA succeeded in meeting a number of important performance objectives; these included launch success rates of 80 percent for scientific balloons and 92 percent for sounding rockets. The sounding rocket and balloon flight programs provide frequent, low-cost flight opportunities to the upper limits of Earth's atmosphere for scientific research and testing of technology. These suborbital flights are also the primary opportunity to train graduate students and young scientists in hands-on flight research techniques. In the Balloon Program, the High-Energy Replicated Optics scientific balloon flight in May 2001 was the first flight mission of any type to use focusing hard X-ray optics, a new type of instrument. This important advance potentially allows observations of objects that are 10 to 100 times fainter than those that can be detected with other instruments. This will certainly lead to significant new discoveries. On the Next Generation Space Telescope, the use of an alternative technology and a delay in procurements caused the assigned metric to be missed. However, the decision to use an alternative technology produced cost savings, and the procurement delay allowed the project to achieve a more mature state of technology readiness prior to contractor selection, which is also likely to produce cost savings during the mission's development. Next Generation Space Telescope will replace the highly successful Hubble Space Telescope when it retires near the end of the decade. Over the telescope's 5- to 10-year lifetime, astronomers hope to observe the farthest reaches of the universe.



**NASA telescope goes where none have gone before**

7 June 2001. Since 1931, when Karl Jansky accidentally invented the radio telescope, astronomers have found again and again that there is more to the universe than the human eye can see. Indeed, every part of the electromagnetic spectrum has offered one surprise or another to astronomers. Now, say astronomers, we should prepare to be surprised again.

Scientists at NASA's Marshall Space Flight Center opened a new wavelength band for high-sensitivity astronomy: "hard" x-rays. Hard x-rays are photons with about the same energy as medical x-rays (> 10 keV), or ~20,000 times more energy than visible light. Such x-rays reveal some of the most violent phenomena in the universe, including colliding galaxies, fiery stellar explosions, and hot disks that swirl around black holes. Astronomers have flown hard x-ray detectors before, but until now none could focus the radiation to produce crisp images with high sensitivity.

Using a revolutionary telescope floating on a balloon 25 miles above Earth's surface, Marshall scientists captured focused hard x-ray images of Cygnus X-1 (a black hole accretion disk) and the Crab Nebula (the seething remnant of a supernova explosion shown above) and its pulsar. They are the first such pictures of any heavenly body.

*Explore the Solar System*

Exploration of our solar system revolutionizes our understanding of physics, chemistry, and biology. Earth and all 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 NASA 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? In FY 2001, NASA made excellent progress in all areas of this objective.

The fifth Discovery Program mission, Genesis, successfully launched in August 2001. Genesis will collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis after an airborne capture in the Utah desert. Such data are critical for improving theories about the formation of the Sun and the planets, which formed from the same primordial dust cloud. The Mars Odyssey mission, which will improve our understanding of Mars' climate and geologic history, was launched in April 2001.

The scientific data received from operating missions during FY 2001 were excellent. The Mars Global Surveyor exceeded expectations in completing its primary mapping mission, and Mars Odyssey operations commenced; both will help build a comprehensive data set to plan future robotic and eventual human missions to Mars.

NASA's space science performance in the area of technology development and supporting research was very good, with few exceptions due largely to external causes. Solar-B was delayed due to a Japanese-initiated launch delay. The budget impact of the Solar-B delay has also led to a delay in the Solar Terrestrial Relations Observatory launch date. Both Solar-B and the Solar Terrestrial Relations Observatory will help to answer the questions of how and why the Sun varies, thereby improving the ability to predict and provide warning of such variations. Fortunately, these launch delays will not diminish the science gained once these missions are operational. Preliminary concept definitions for future Solar Terrestrial Probe spacecraft and instruments to study the Sun-Earth system were completed. Also, technological progress made in advanced avionics by the Center for Integrated Space Microsystems will enable more compact, low power, and lightweight deep space orbiters, landers, and flyby spacecraft.

*Discover Planets Around Other Stars*

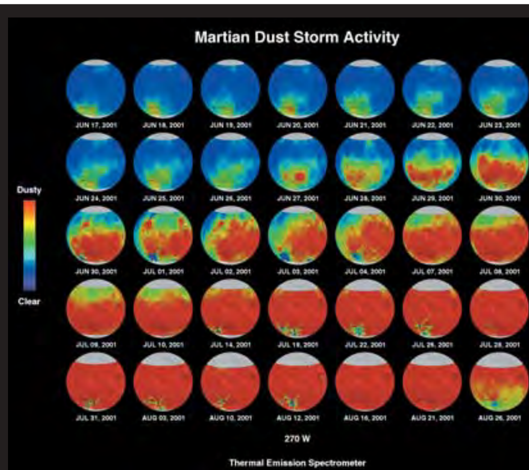
Determining whether habitable or life-bearing planets exist around nearby stars is a fundamental goal. In addition, learning about other nearby planetary systems will provide valuable context for research on the origin and evolution of our own solar system. Discovering other planets outside of our solar system requires greater knowledge of the positions and distances of the stars and galaxies. Optical interferometry will enable us to make these determinations with far greater accuracy than previous programs. In FY 2001, NASA's performance in pursuit of this objective was mixed.

Despite the numerous technical challenges inherent in efforts to image and characterize planets around other stars, NASA made progress in technology development in this area. The earlier rephasing of the Starlight-3 mission to align it with the Terrestrial Planet Finder mission set a new schedule that is not compatible with previously established metrics, but progress in FY 2001 was good. The Starlight-3 mission is designed to demonstrate technologies that would later enable the Terrestrial Planet Finder to detect Earth-sized planets around stars. Furthermore, NASA advanced Terrestrial Planet Finder technical development by awarding contracts for architectural definition and technology planning, and successfully testing the infrared nulling breadboard. This technology demonstrates the principle that the light received directly from a planetary system's star can be masked to allow the light reflected off of the individual planets to be identified. NASA succeeded in combining the two Keck telescopes, creating a single optical instrument powerful enough to pinpoint planets orbiting other stars. The new design concept created for the Space Interferometry Mission, which will detect planets around other stars and precisely locate very dim stars to an unprecedented accuracy, delays launch of the mission, but will not diminish its science value.

*Search for Life Beyond Earth*

Perhaps the most elusive and intriguing question space science seeks to answer is "Are we alone?" NASA has in place a well-developed strategy to investigate suitable environments for life in and beyond our solar system. Performance in pursuit of this objective exceeded expectations in FY 2001.

The Mars Global Surveyor completed its primary mapping mission and continued its unprecedented success in its extended mission during FY 2001. The Mars Global Surveyor mapped landing sites for the 2003 Mars Exploration Rover mission, monitored the largest planet-encircling dust storm since 1971, and discovered potential




**NASA maps Martian dust storm**

The largest dust storm seen on Mars since NASA's Mars Global Surveyor spacecraft arrived in 1997 raged across the planet in 2001. Earth has dust storms, too, but the planet-girdling storms on Mars dwarf their terrestrial counterparts. The Mars Global Surveyor has been tracking the temperature changes that trace the amount and location of dust in the atmosphere using a thermal emission spectrometer.

Because Martian dust storms not only cloud the Red Planet's air but also heat up airborne dust particles, the atmosphere warms and expands during the storms. This affects Mars-orbiting spacecraft by increasing the amount of aerodynamic drag at orbital altitudes. Consequently, the team operating NASA's 2001 Mars Odyssey spacecraft is closely monitoring the storm.

evidence of present-day climate change. The Mars Odyssey mission was successfully launched in FY 2001. It has since arrived at Mars and has begun a new phase of scientific reconnaissance. High-resolution orbital imaging will follow up on Mars Global Surveyor results that suggest the presence of near-surface water in recent times.

The Terrestrial Planet Finder mission continued procurement activities, and successfully tested the Starlight nulling breadboard. The Terrestrial Planet Finder will be able to search about 200 nearby stars for planets that possess atmospheres that would indicate the possible presence of life.

The NASA Astrobiology Institute exceeded its goals for the year, and was quite successful in sharing the results of its work beyond the traditional science community. The mission of astrobiology is to study the origin, evolution, distribution, and future of life on Earth and in the universe. The Institute's education and public outreach efforts included three teacher workshops, and the production of classroom materials, web casts, and Internet resources. The Institute also held multiple public lectures and produced general interest publications, such as *Astrobiology: the Search for Life in the Universe*.

The only FY 2001 performance metric not achieved for this objective involved a delay in completing the Preliminary Design Review for the Europa Orbiter. The objective of the Europa Orbiter mission is to 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 mission, in its present form, has since been cancelled due to projected cost increases. Future Europa mission concepts could compete for selection under the New Frontiers Program.

## Challenges

NASA's space science endeavors are by nature high-risk. It is by pursuing cutting-edge technological advances that the Agency succeeds in developing missions that produce cutting-edge science. The next generation of spacecraft that will carry out this broad program of exploration must be more capable and more reliable, while being more efficient in mass and power consumption. Instruments must be capable of performing in the harsh environments of extreme temperatures and intense radiation fields. Current mission concepts call for advances in ultra-lightweight materials, high rate data delivery, micro-spacecraft, and the ability to fly multiple spacecraft in precisely aligned formation.

Such challenges are the reason that much effort is expended on technology development early in a mission's lifecycle. Examining and testing various technologies are essential steps in the process of reducing risk prior to devoting substantial budget resources to a particular mission concept.

## Assessments

Eight of nine FY 2001 annual performance goals were achieved. As can be seen from the following table, we were successful in achieving goals aimed at obtaining scientific data from operating missions, as well as advancing the search for life beyond Earth, developing and launching two missions, and performing innovative scientific research and technology development objectives for major projects (blue and green). We did not meet one goal aimed at launching four planned missions (yellow). It should be noted that while this goal was not achieved, progress was significant and achievement is anticipated within the next fiscal year.

**Strategic Goal 1. Chart the evolution of the universe from origins to destiny, and understand its galaxies, stars, and life**

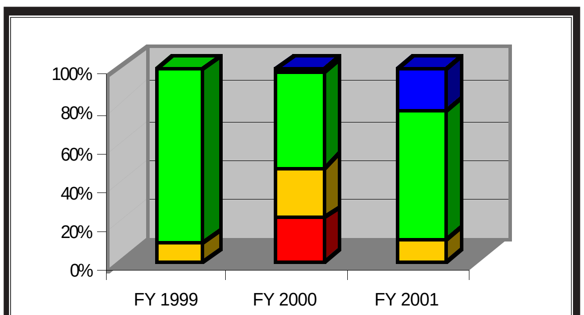
| APG | Description | Assessment |
|---|---|---|
| 1S1 | Successfully develop and launch no fewer than three of four planned missions within 10% of budget and schedule. Missions are: Galaxy Evolution Explorer (GALEX), Microwave Anisotrophy Mission (MAP), Gravity Probe B (GP-B), and Cooperative Astrophysics and Technology Satellite (CATSAT). | Yellow |
| 1S2 | Obtain expected scientific data from at least 80% of operating missions. Missions are: Hubble Space Telescope (HST), Chandra X-ray Observatory (CXO), Rossi X-ray Timing Explorer (RXTE), Advanced Composition Explorer (ACE), Far Ultraviolet Spectroscopic Explorer (FUSE), Submillimeter Wave Astronomy Satellite (SWAS), and, if successfully launched, GALEX, and GP•B. | Blue |
| 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: Next Generation Space Telescope (NGST), Herschel Far Infrared and Submillimeter Telescope (FIRST), Gamma Ray Large Space Telescope (GLAST), Sounding Rockets, Balloons, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee. | Green |
| 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. | Green |

*(Assessment table continued)*

| **Strategic Goal 1. Chart the evolution of the universe from origins to destiny, and understand its galaxies, stars, and life** | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 1S5 | Obtain expected scientific data from at least 80% of operating missions. Missions are: Cassini; Voyager; Ulysses; Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX); Fast Auroral Snapshot Explorer (FAST); Transition Region And Coronal Explorer (TRACE); Stardust; Mars Global Surveyor; and International Solar-Terrestrial Physics Program (ISTP) spacecraft; also, if successfully launched, Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED), High Energy Solar Spectrographic Imager (HESSI), Imager for Magnetopause-to-Aurora Global Exploration (IMAGE), Genesis, and Mars Odyssey ('01 Orbiter). | |
| 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, Solar Terrestrial Relations Observatory (STEREO), Solar Probe, Future Solar Terrestrial Probes, Future Deep Space Technology, Center for Integrated Space Microsystems (CISM), X-2000, Sounding Rockets, and Balloons. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee. | |
| 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 Space Interferometry Mission (SIM), Terrestrial Planet Finder (TPF), StarLight 3 (ST-3), Keck, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee. | |
| 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. | |
| 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. | |

## Trends

Overall, 89 percent of the annual performance goals associated with this strategic goal were achieved (green and blue). This represents an increase from FY 2000, when 51 percent of the goals were achieved. FY 2001 performance was notable in that 22 percent of the goals were not only achieved but also exceeded (blue).




Annual performance goal achievement in charting the evolution of the universe increased from FY 2000 to FY 2001, but decreased from FY 1999.

**Strategic Goal 2. Contribute Measurably to Achieving the Science, Math, and Technology Education Goals of Our Nation**

NASA is committed to making measurable contributions towards achieving the science, math, and technology education goals of our Nation. To achieve this goal, education and enhanced public understanding of science have become an integral part of each mission and research program. No space science flight mission or research project is complete until the excitement and discoveries from that mission or project have been made available and accessible to the education community and to the public.

Achievements

The extent and breadth of NASA's education and public outreach activities in FY 2001 were substantial, with over 400 NASA-funded educational products developed and activities carried out during the year. Taking into account that many of these activities involved multiple events that took place in a variety of venues, the total number of education and public outreach events in FY 2001 was nearly 3,000, with events taking place in all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.

*Make Education and Enhanced Public Understanding of Science an Integral Part of Our Missions and Research*

Included within these activities were special efforts to respond to the needs of various groups. The need to increase the numbers of underrepresented minorities with interests in and understanding of space science was addressed in part through a set of 15 grants to minority colleges and universities for the purpose of developing Space Science capabilities in education and/or in research on their campuses. The need to provide content resources to educators was addressed in part by providing a space science presence through exhibits, materials, workshops, and personnel at 20 national and 40 regional education and outreach conferences. The need to provide public access to recent space science missions and discoveries was addressed in part through five major, NASA-sponsored exhibits or planetarium shows on display or on national tours at major science museums or planetariums across the country.

All of these FY 2001 activities and events are publicly documented in the Space Science Enterprise Education and Public Outreach Annual Report, available by March 2002 in a searchable, on-line version at http://ossim.hq.nasa.gov/ossepo/2001/index.html.

The trends in these measures show, in general, substantial increases from FY 2000 to FY 2001 in the numbers reported. The number of education and public outreach activities increased by more than 25 percent and the number of events doubled. The number of NASA-participating national education and outreach conferences increased by more than 25 percent, and the number of regional conferences doubled. The number of major exhibits or planetarium shows on display or on tour did not change.

Several of the major science center exhibitions on display or developed during FY 2001 are a direct result of collaborations with the Smithsonian Institution and joint funding by the National Science Foundation. Such collaborations take advantage of the science content that is the Space Science program's primary resource, and leverage it through the expertise of the Smithsonian at developing and displaying exhibits, and the funding available from the National Science Foundation to support such exhibits.

A comprehensive evaluation of the Space Science Education and Public Outreach Program is being conducted under the leadership of the Program Evaluation and Research Group at Lesley University in Cambridge, Massachusetts. Their second written report, focusing on issues affecting the implementation of the program, was received in September 2001. Report findings and recommendations help guide the adjustments being made to increase the number of projects embedded in small research grants. In addition, a Task Force of the Space Science Advisory Committee will conduct a comprehensive review of the program during FY 2002 and FY 2003.

### Challenges

The rapid growth of the Space Science Education and Public Outreach program, coupled with the fact that it is by design a highly leveraged and broadly distributed program, make it a challenge to collect information concerning the program's full extent and impact. Capturing complete and accurate data on all activities conducted in a program of the scope and scale of this effort is a major undertaking, considering the small size of the program staff. Nevertheless, procedures for collecting this data were developed and are being continually improved with the goal of making the resultant Annual Report on Enterprise Education and Public Outreach activities more complete and comprehensive. Major activities have also been organized to assess the effectiveness and impact. A task force of the Space Science Advisory Committee was set up to examine the effectiveness of the Implementation Plan, which is the foundation of our approach to education and public outreach. In addition, an independent evaluation team from the Program Evaluation and Research Group at Lesley University, which has worked with the Office of Space Science for the past 3 years, is collecting evidence of the outreach program's impact on the education community. Both of these studies will provide valuable feedback to be used to guide future program modifications and improvements.

### Assessments

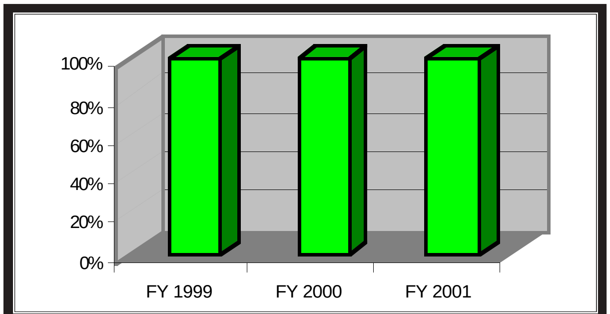
The sole annual performance goal was achieved. As the table shows, we continued to expand the integration of education and public outreach with space science research and flight mission programs. We sponsored over 400 space science education and public outreach activities during the fiscal year.

**Strategic Goal 2. Contribute measurably to achieving the science, math, and technology education goals of our Nation**

| APG | Description | Assessment |
|---|---|---|
| 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. | ● |

### Trends

Overall annual performance goal achievement in contributing measurably to achieving the science, math, and technology education capabilities of our Nation was 100 percent for the past 3 years.




NASA continues outstanding performance in contributing to science, math, and technology education

**Strategic Goal 3. Support Human Exploration Through Robotic Missions**

NASA seeks to investigate the composition, evolution, and resources of Mars, the Moon, and small bodies. Space Science is also working to develop the knowledge required to improve the reliability of space weather forecasting.

Achievements

Scientific exploration of Mars continues, with the successful insertion of Mars Odyssey into orbit around the planet on October 23, 2001, concluding its long journey to this exciting world. Mars Odyssey has joined the Mars Global Surveyor, in orbit now for more than 4 years, which is mapping landing sites for the 2003 Mars Exploration Rover. As part of this program, the Mars Global Surveyor has been monitoring the largest, planet-encircling dust storm since 1971, in conjunction with Hubble Space Telescope imaging from Earth orbit.

*Investigate the Composition, Evolution, and Resources of Mars, the Moon, and Small Bodies*

These Mars missions serve the important purpose of expanding our knowledge of the environment and conditions on Mars suitable for more advanced landing and exploration capabilities. A fuller understanding of the environment around Mars, for example, will be of significant public benefit in optimizing both our future robotic and possible human exploration missions to this world.

A major collection of Mars Global Surveyor research articles was published in the *Journal of Geophysical Research (Planets)* and Mars discoveries made the cover of major science journals (*Nature* and *Science*).

The investigation of small bodies in the solar system is concentrating on the structure and composition of these numerous objects, generally thought to be some of the most ancient materials in our celestial neighborhood. The Stardust mission continues on course to rendezvous with and sample the composition of Comet Wild 2 in early 2004. Recently, it achieved the milestone of being the manmade object to travel farthest from the Sun powered only by solar energy. The Comet Nucleus Tour mission, which will improve our understanding of the key characteristics and diversity of comets, successfully completed its Critical Design Review (a key mission milestone) in FY 2001, and development proceeds toward a 2002 launch.

Progress toward this Strategic Plan objective was significant in the last several years. Scientific exploration of Mars has proceeded smoothly since the loss of Mars Climate Orbiter and Mars Polar Lander in 1999. The Mars program was redesigned and replanned during 2000, and the current suite of missions is the result of that effort. Development of Mars Exploration Rover and the Mars Reconnaissance Orbiter continues with the solicitation of Mars Reconnaissance Orbiter instruments and spacecraft and construction continuing of the twin rovers. Exploration of the Solar System's small bodies will intensify and broaden over the coming few years with the launch of the Comet Nucleus Tour to Comets Encke and Schwassmann-Wachmann 3, and Deep Impact to Comet Tempel 1.

*Develop the Knowledge to Improve the Reliability of Space Weather Forecasting*

Solar variability affects life and society by causing "space weather," which can affect space assets vital to the national security and economy (communications, military, and weather satellites), short wave radio communications, the electric power grid, and astronauts. Solar variability also is a natural driver of global climate change, which


**NASA studies space weather**
What is happening above the sunspot? The Transition Region and Coronal Explorer spacecraft caught these coils of hot, electrified gas, known as coronal loops above active sunspots. The loops (some more than 300,000 miles high and capable of spanning 30 Earths) rise while flowing along the solar magnetic field, then cool and crash back to the surface at more than 60 miles per second.

appears to have affected Earth's climate in the past. Exploration of the complex interplay of forces and processes between the Earth and Sun remains among the highest priorities of NASA's Space Science program, and continues with the highly successful Solar Heliospheric Observatory and Transition Region and Coronal Explorer missions, and the important progress made in the Living With a Star Program.

Over the past 2 years, NASA missions conducted observations in increasing detail, with more sophisticated analysis possible using the long-lived Solar Heliospheric Observatory and Transition Region and Coronal Explorer spacecraft. The key characteristic trend of progress in achieving this strategic plan goal has been the increasing use of multiple spacecraft, observational capabilities that have come on line over the past few years and analysis tools that permit multiple observations to investigate a particular science question.

Our science missions are dramatically advancing our knowledge of how the Sun works; for example, through studies of solar interior dynamics. With a growing fleet of spacecraft, NASA is increasingly able to make coordinated measurements of events that start at the Sun, propagate through space, and impact the Earth's magnetosphere and upper atmosphere. These coordinated observations permit a variety of insights into how the Sun works. For example, using telescopes from ground observatories, a Living with a Star research effort discovered that the long-term as well as seasonal changes in the amount of sunlight reflected by Earth can be measured by its illumination of the Moon. This method provides a unique way of measuring variations in solar energy due to changes in the Earth's atmosphere, knowledge that is helpful in understanding global climate change.

In a particularly valuable breakthrough, the Michelson Doppler Imager instrument on the Solar Heliospheric Observatory discovered how to "see" through the Sun, a technique which is now used on a daily basis to study sources of activity on the far side of the Sun. This is a potentially powerful tool, as it allows observations of submerged developing activity and provides warnings of the growth of potentially hazardous active regions fully a week before they come into view on the Sun.

The Solar Heliospheric Observatory also discovered how a sunspot is formed. The Michelson Doppler Imager instrument enabled us to peer below the solar surface and observe the subsurface structure and measure key characteristics of these intriguing features to help explain how they work.

## Challenges

In planning for future human exploration, significant concerns exist regarding radiation exposure during long-duration missions beyond Earth orbit. The Living with a Star program will provide more precise characterization and understanding of this risk. Efforts continue to develop the critical technologies, such as miniaturization of spacecraft subsystems and instruments that will enable the required investigations.

## Assessments

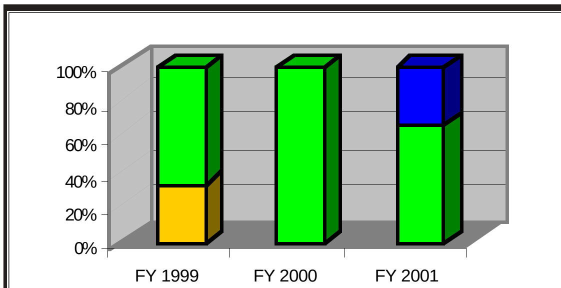
One of three annual performance goals we pursued in FY 2001 was exceeded (blue)—the investigation of Mars, the Moon, and small bodies, and two annual performance goals were achieved (green)—developing the knowledge to improve the reliability of space weather forecasting, and furthering understanding of the basic natural processes and the effects of solar variability on humans and technology.

**Strategic Goal 3. Support human exploration through robotic missions**

| APG | Description | Assessment |
|---|---|---|
| 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 Research and Analysis (R&A) and Data Analysis (DA) programs. Meet no fewer than 75% of the performance objectives for Mars Odyssey ('01 Orbiter), Comet Nucleus Tour (CONTOUR), Mars Global Surveyor, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee. | Blue |
| 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, Advanced Composition Explorer (ACE), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), Transition Region And Coronal Explorer (TRACE), International Solar-Terrestrial Physics Program (ISTP), and, if successfully launched, High Energy Solar Spectrographic Imager (HESSI). Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee. | Green |
| 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 the following Living With a Star program elements: 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. | Green |

## Trends

Overall, all annual performance goals were achieved in FY 2001. Of those, 67 percent were achieved (green) and 33 percent were not only achieved but also exceeded (blue). Moreover, the graph shows that annual performance goal achievement consistently increased from FY 1999 to FY 2001.



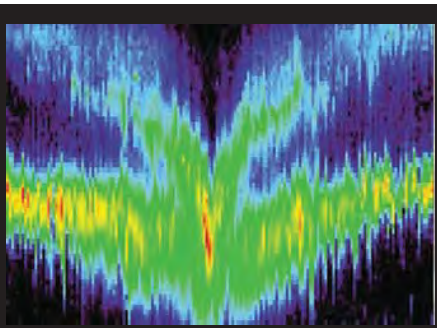

FY 2001 annual performance goal achievement in supporting human exploration through robotic missions increased substantially over a 3-year period.

**Strategic Goal 4. Develop New Technologies Needed to Carry Out Innovative and Less Costly Mission and Research Concepts**

The space science technology program encompasses three key objectives:

1. Development of new and better technical approaches and capabilities;
2. Validation of these improved and demonstrated approaches so that they may be used in flight missions; and
3. Infusion of these capabilities into our missions and, where possible, transfer to U.S. industry for public good.

NASA continues to work with the Commercial Technology Division to seek ways in which these technologies can more effectively be made accessible to the U.S. economy. Particular examples during this past year include presentations and discussions of NASA technologies at national conferences on robotics, sensors, and advanced household appliances.



**NASA extends successful Deep Space 1 mission for encounter with a comet**

Deep Space 1 completed its primary mission testing ion propulsion and 11 other advanced, high-risk technologies in September 1999. NASA extended the mission, taking advantage of the ion propulsion and other systems to undertake this chancy but exciting, and ultimately successful, encounter with the comet.

Deep Space 1 flew by comet Borrelly on September 22, 2001 and took these measurements with its plasma instruments between 56,000 and 1,200 miles away. These data show that the flow of ions around the comet's rocky, icy nucleus (the center of the deep V-shaped feature) is not centered on the comet's nucleus as scientists expected before the Borrelly flyby. Ions in the turbulent flow are heated to about 2 million degrees Fahrenheit, causing the bands of ions to appear broad and jagged compared to the solar wind.

Achievements

The New Millennium Program is probably the best example of how NASA's space science program manages the development and infusion of technologies. Over the past several years, this program has been soliciting, selecting, and flying technologies that are of increasing value to space science. Since launch, Deep Space 1 has demonstrated 12 advanced technologies in space, a number of which are highlighted as priorities for future missions, notably electric propulsion. Recently, Deep Space 1 flew by Comet Borrelly as part of a very successful extended mission.

The New Millennium Program, with its advanced technology focus, is one of NASA's many efforts to develop and test an arsenal of cutting-edge technologies and concepts. Once proven to work, these technologies will be used by future missions to explore the universe. Deep Space 1, which was launched in 1998, was the first in a series of deep space and Earth-orbiting missions that the program is conducting to demonstrate new technologies in the environment of space.

Challenges

A significant portion of NASA's long-range technology investment to achieve Space Science missions resides within NASA's aerospace technology effort. In FY 2001, both organizations worked to better specify mission needs and to implement joint funding of priority technologies.

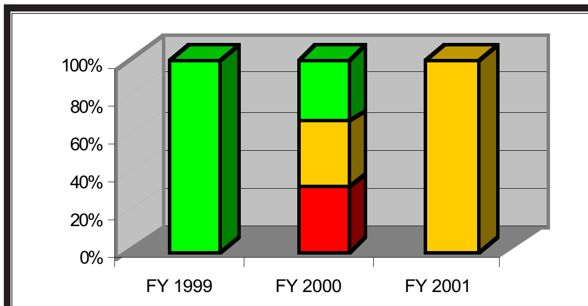
Assessments

We did not meet the annual performance goal in our core technology programs (yellow) due the redirection of funding for high-performance computing to support other higher-priority programs. However, significant progress was made in planning, developing, and validating new technologies.

| Strategic Goal 4. Develop new technologies needed to carry out innovative and less costly mission and research concepts | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 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. | ● (yellow) |

Trends

NASA did not achieve (yellow) the annual performance goal associated with this strategic goal to develop new technologies needed to carry out less costly mission concepts in FY 2001, although progress was significant and achievement is anticipated within the next fiscal year. This represents a decrease from prior fiscal years.




NASA's performance in new technology shows some decline across a 3-year period.

## Awards, Honors and Distinctions

During FY 2001, NASA was honored to receive, from the Administration, the President's Award for Design Excellence for the Mars Pathfinder mission, citing "outstanding achievement in design."

Space science education and public outreach projects received over 40 awards from external organizations during the year, including over 20 awards for excellence in educational web sites. These awards include such prestigious honors as the Infinity Award for Applied Photography to the Hubble Space Telescope Heritage Program for valuing "both scientific information and aesthetic presence" in producing celestial photographs, and the International Technology Education Association's Presidential Citation to the New Millennium Program's Space Place Team "for efforts above and beyond the call of duty in service to the Technology Education profession."

The Microwave Anisotropy Probe Explorer mission, launched in June 2001, was cited as one of the best innovations in aviation and space in the December 2001 issue of *Popular Science* magazine. Throughout the year, *Popular Science* reviews new products and technologies and features the finest in its annual "Best of What's New" edition.

Each recipient is chosen for its ability to improve in some way the quality of life. The Microwave Anisotropy Probe will scan the sky for over 2 years, gathering information on the faint cosmic glow. Scientists hope to determine the content, shape, history, and the ultimate fate of the universe, by constructing a full-sky picture of the 14-billion-year-old light left over from the Big Bang. The patterns in this light across the sky contain a wealth of details about the nature, composition, and destiny of the universe.

**NASA wins the Infinity Award for Applied Photography**

Examples such as the image of the "ant nebula" (Menzel 3, or Mz 3) shown above easily demonstrate why NASA not only garners awards for science but also for photography. This dramatic Hubble Space Telescope image reveals the "ant's" body as a pair of fiery lobes protruding from a dying, Sun-like star.

Hubble images such as this one directly challenge old ideas about the last stages in the lives of stars. By observing Sun-like stars as they approach their deaths, the Hubble Heritage image of Mz 3—along with pictures of other planetary nebulae—shows that our Sun's fate probably will be more interesting, complex, and striking than astronomers imagined just a few years ago.

Though approaching the violence of an explosion, the ejection of gas from the dying star at the center of Mz 3 has intriguing symmetrical patterns unlike the chaotic patterns expected from an ordinary explosion. Scientists using Hubble would like to understand how a spherical star can produce such prominent, non-spherical symmetries in the gas that it ejects.

Space science also figured prominently in the tenth annual calculation of the *Science News* metric, which is based on scientific discoveries covered in *Science News* magazine. The review covers all fields of science and is used to measure contributions to world scientific discovery and technological achievement. While NASA programs accounted for an impressive 8 percent of worldwide discoveries during 2001, space science programs alone accounted for 7 percent. The Hubble Space Telescope produced a quarter of these, including the detection of a planet's atmosphere that lies beyond our solar system, the identification of a clump of stars that may be one of the first building blocks of a galaxy, and evidence that a mysterious force is pushing galaxies apart at an ever-faster rate. Other space science contributions include advances in our understanding of black holes that have resulted from Chandra X-ray Observatory observations, and evidence from the Mars Global Surveyor regarding recent climate changes on Mars.

## Partnerships

NASA's space science program exists within a much larger research and technology context that spans the globe. In some areas space science leads the pace of innovation, and in others it benefits from efforts and investments of others. NASA's pace of discovery is quickened by contributions from other U.S. Government agencies, U.S. universities and industry, and scientific collaborators around the world.

### Other U.S. Government Agencies

The National Science Foundation has many programs that support or enhance NASA space science missions. The National Science Foundation supported ground-based research on the Sun, the planets, and the universe that contributes to the intellectual foundations of many NASA space science flight missions. NASA and the National Science Foundation jointly fund planet search programs. The National Science Foundation is also responsible for U.S. scientific activities in the Antarctic, which include long-duration balloon missions and work on Antarctic meteorites.

The U.S. Department of Energy similarly has a wide range of programs that support NASA space science activities. The U.S. Department of Energy has developed and supplied the radioisotope thermoelectric generators that have enabled a wide range of Solar System exploration missions—from Apollo to Viking to Voyager, as well as the Galileo and Cassini/Huygens missions to the outer planets. The U.S. Department of Energy has also developed instruments and sensors for NASA's space science missions, particularly through its Los Alamos and Lawrence-Livermore Laboratories. The U.S. Department of Energy and NASA have jointly studied a mission to place high-energy particle detectors in space aboard both satellites and the International Space Station, and the agencies are combining their talents in working to build and fly the Gamma-ray Large Area Space Telescope.

For its part, the U.S. Department of Defense has been a major developer of high-sensitivity, large-area infrared detector arrays needed for many space science missions. These arrays and the technology for large-area deployable optical systems are important for future large telescopes in space. Space science, in turn, contributes to U.S. Department of Defense objectives. For example, research on solar flares, coronal mass ejections, and solar energetic particles is important for U.S. Department of Defense command, control, and communications systems. The U.S. Department of Defense and NASA have established a partnership for expanded cooperation on the space environment. In addition, NASA cooperates with National Oceanic and Atmospheric Administration and the U.S. Department of Defense by providing data used for forecasting and understanding the space environment. This effort is part of an interagency (NASA, the National Science Foundation, the National Oceanic and Atmospheric Administration, the U.S. Department of Defense, the U.S. Department of Energy, and the U.S. Department of the Interior) national space weather program.

In the area of education, NASA works with the National Science Foundation and the U.S. Department of Education to use space science missions and programs to contribute to science, mathematics, and technology education, and to share the excitement of space science discoveries with the public.

### Universities

From the very beginning, universities and university scientists have played a central role in the planning and implementation of space science. University scientists serve on NASA study teams and on key advisory committees that lay out long-range goals and objectives, strategies, and priorities for space science. University scientists develop new approaches for making critical measurements, serve as principal investigators for flight investigations, and carry out the long-term laboratory, theoretical, and computational studies required to interpret data returned from space science missions.

The trend towards smaller, more frequent, and lower cost missions, together with the advent of advanced communications and information systems technologies, has allowed universities to take on greater responsibility for the design, development, and operation of entire missions rather than just the development of individual instruments on larger NASA-developed missions. For example, the University of California, Berkeley, is providing detectors and front-end electronics for the Galaxy Evolution Explorer. Support from NASA flight projects and research grant programs is an important contributor to maintaining the infrastructure that permits this university participation. Easier electronic access to archived data and new policies that place science data in the public domain as soon as possible are helping scientists and students at a wide range of institutions, including colleges and smaller universities, to participate in the analysis of NASA science data.

**Industry**

Industry has made and will continue to make significant contributions to the planning, development, and implementation of space science missions and research programs. Industry has played a critical role in the design, engineering, manufacture, construction, and testing of both large and small space missions; in the design, development, testing, and integration of advanced instruments; and in the development of advanced spacecraft, instrument, mission operations, and information system technologies. Many industry capabilities have been developed for industry's commercial applications with the U.S. Department of Defense or NASA's core technology support, resulting in an extensive industrial space infrastructure. Establishing partnerships with industry allows participants in the Space Science Enterprise to better utilize the experience and the capabilities of the industrial sector.

As noted earlier, universities are now partnering with industry to assume full responsibility for the design, development, and operation of entire missions. With increased flight opportunities now being provided through the Explorer, Discovery, and New Millennium programs, such partnerships are likely to play an even more important role in the future.

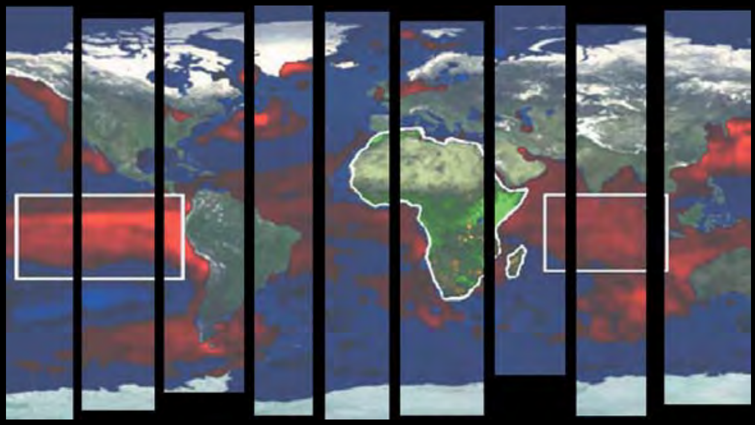
The reliance on the identification, development, and utilization of advanced technology to dramatically lower instrument, spacecraft, and mission operations costs requires strong partnerships between industry and NASA. Strong partnerships are also important for facilitating the transfer of NASA-developed technology to industry and thereby realizing the commercial potential of these technologies and contributing to the long-term capability and competitiveness of American industry.

**Other Nations**

The quest for knowledge does not recognize national boundaries. Scientific expertise and capabilities are today more than ever distributed among many nations. Common interests and limited resources virtually dictate that nations cooperate in the pursuit of common goals. Further, the Space Act specifically mandates a leadership role for NASA in promoting international cooperation in space research, such as NASA's participation in the Planck and Herschel missions, which are partnerships with the European Space Agency. For all of these reasons, international cooperation is a fundamental aspect of virtually all NASA space science programs.

# Earth Science

*NASA's Earth science mission is to understand the total Earth system and the effects of natural and human-induced changes on the global environment. Our programs advance the new discipline of Earth system science, with a near-term emphasis on global climate change. Both space- and ground-based capabilities yield new scientific understanding of Earth and practical benefits to the Nation. The research results will contribute to the development of environmental policy and economic investment decisions. The mission includes the development of innovative technologies to support Earth science programs and make them available for solving practical societal problems in agriculture and food production, water resources, and national resource management that provide benefits to the Nation. We share our knowledge and discoveries with the public to enhance science, mathematics, and technology education, as well as increase the scientific and technological literacy of all Americans.*



# Earth Science

## Strategic Goals

To achieve the Earth science mission, NASA has specified three strategic goals:

1. Expand scientific knowledge by characterizing the Earth system
2. Disseminate information about the Earth system
3. Enable the productive use of Earth systems science and technology in the public and private sectors

### Strategic Goal 1. Expand Scientific Knowledge by Characterizing the Earth System

The use of space to conduct cutting-edge research on the Earth system has become a NASA hallmark. In FY 2001, numerous satellite missions, field campaigns, and data analyses greatly improved our understanding of the Earth system. Knowledge was gained in understanding and explaining the dynamics of Earth's global carbon cycle, global water cycle, long-term climate variability, atmospheric composition, and the planet's interior and crust.

Achievements

Understanding how the Earth is changing and the consequences for life on Earth will contribute to the development of sound environmental policy and economic investment decisions. NASA's space-based observation of the interactions among land, atmosphere, ice, oceans, and life advances the new discipline of Earth system science to answer key questions about global change: 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 change in the Earth system for human civilization? How well can we predict future changes in the Earth system? NASA's Earth science mission combines the excitement of scientific discovery with the reward of practical contribution to the sustainability of planet Earth.

The following sections describe FY 2001 achievements in expanding scientific knowledge by launching the first Earth Observing System satellites to characterize the Earth system, including the global carbon cycle, global water cycle, long-term climate variability, atmospheric composition and chemistry, and the dynamics of Earth's interior and crust.

*Spacecraft*

Launching spacecraft with cutting-edge technology and instruments in a timely and cost-effective manner is a key element in ensuring the continued success of Earth system research and analysis. The flawless launch and activation of the first Earth Observing technology demonstration satellite furthered all three strategic goals and served as a springboard for future scientific research.

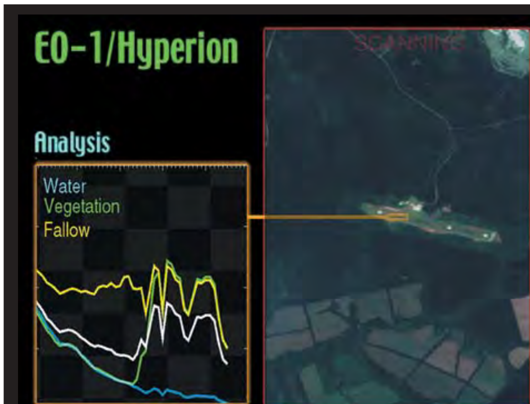
The mission's main purpose was to demonstrate newer and cheaper technologies than those aboard current standard Landsat series. At one-quarter the weight and one-third the cost of traditional Landsat satellites, the first Earth Observing technology demonstration satellite, Earth Observing-1, demonstrates the ability to produce Landsat-like imagery at a fraction of previous Landsat mission costs.

In addition to reducing mission costs, Earth Observing-1 demonstrated breakthrough technology. It contains three observing instruments supported by a variety of newly developed space technologies. Several of the technologies, once validated, will be turned over to the private sector for commercial development. The Earth Observing-1 satellite also flies in formation with the Terra satellite, Landsat-7, and a joint United States-Argentina satellite to demonstrate the satellite constellation concept in which the combined capabilities create a super-satellite capable of observing the same locations at a variety of spatial and temporal scales.

*Land Cover, Land Use*

NASA is actively involved in determining how land cover and climate changes affect agricultural productivity and the planet's overall health. The carbon cycle is one of the major Earth system processes influencing global climate. Earth science research on ecosystems and the global carbon cycle aims to understand and predict how terrestrial and marine ecosystems are changing 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.

In FY 2001, NASA made substantial progress in creating a multi-year, global data set showing how terrestrial and marine ecosystems change over time. Key to this progress is merging data from successive satellites into a continuous data record, which NASA began this year with data from the Sea-Viewing Wide Field-of-view Sensor launched in mid-1997 and the Terra satellite launched in December 1999. NASA was able to correlate the ocean phytoplankton fluorescence observations from Terra with actual phytoplankton concentrations in U.S. coastal waters. In addition to their scientific value in carbon cycle research, such data are employed by commercial fishing operations to locate the best fishing spots. On land, the record of 98 foot resolution land cover data over the whole globe was updated by Landsat-7. Such data provide the basis for establishing rates and patterns of change in global land use and land cover.




**NASA gives us a new look at Earth**

The Hyperion instrument aboard NASA's Earth Observing-1 satellite sees the Earth from space in a new way. Instead of detecting light in only 3, or even 30 wavelengths, it detects 220 distinct wavelengths of light. So many, in fact, that it observes a virtually continuous spectrum of light from .4 µm (blue) to 2.5 µm (mid-infrared). The image above shows a true-color Hyperion image of Argentina (composed of red, green, and blue channels). Superimposed on the image is the spectrum of light reflected from the area highlighted in orange (white line). Compare that to the spectrum of water (blue line), vegetation (green line), and fallow land (yellow line). Known as hyperspectral data, Hyperion's measurements will enable scientists to distinguish different types of surface features—not only vegetation from water, but also soybeans from corn, pine trees from oaks, and sand from dust.

*Seasonal-to-Interannual Climate Prediction*

A key issue addressed by NASA is how Earth's water reservoirs are being renewed. Current Earth science program activities in this area are: establishing the existence (or absence) of a trend in the rate of the global water cycle, investigating the relationships between large-scale climate anomalies and weather patterns, and accurately representing the integrated effect of water vapor absorption and clouds in a way that is suitable for use in models of climate. By improving the understanding of the global water cycle, useful predictions at a regional level can be made that are essential for managing Earth's water resources.

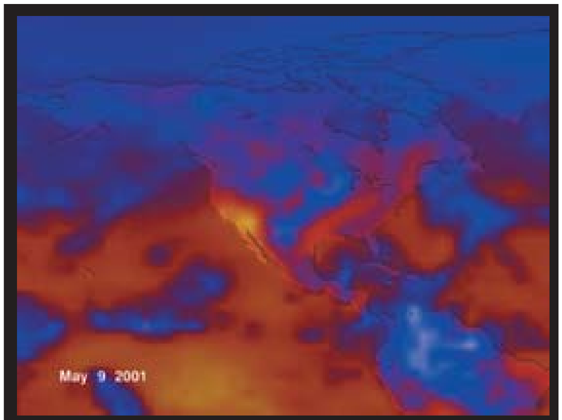
In FY 2001, NASA continued to invest in observations, research, data analysis, and modeling in this area. The Tropical Rainfall Measuring Mission, launched in 1997, is gathering improved information on rainfall in the tropics. Two-thirds of global precipitation falls in the tropics. Data from the Tropical Rainfall Measuring Mission led to an 80-percent improvement in tropical rainfall measurement that will help NASA understand the Earth's hydrological cycle. Since the Earth's hydrological cycle is one of the three major processes driving long-term climate change in our environment, the improved data are very valuable. The data are also important in understanding the global heat balance that drives seasonal change.

In addition, NASA-funded researchers published a paper in *Geophysical Research Letters* showing a relationship between increased solar activity and increased cloudiness over the United States. The paper suggested that solar activity affects the jet stream over North America, causing a change in cloud cover patterns that influence seasonal weather patterns.

*Long-Term Climate Change Detection*

NASA conducts research aimed at understanding, modeling and predicting near- and long-term climate variability on both regional and global scales. We now understand that the climate is not static but dynamic, and will evolve in the future. This research focuses on determining dynamics of the slower components of the physical climate system–the ocean circulation, and the mass balance of polar ice sheets. These components take longer to respond to environmental changes than does the atmosphere.

We are also sponsoring research on the changes in the polar ice sheets, whose melting would increase sea levels. In FY 2001, NASA assessed the rate of change in the Antarctic ice sheet by comparing the resulting map from the second Antarctic Mapping Mission with the first map made in 1998. Ice flows from the interior of the continent to the oceans. NASA-sponsored researchers were able to determine for the




**NASA gauges California heat wave**

This image shows the thermal energy or heat emitted from the United States during May 2001. The record-setting high temperatures experienced in Southern California and Nevada on May 9 are visible in the yellow areas, where great amounts of thermal energy are escaping to space.

The levels of energy on such images increase from blue to red to yellow. The greatest amounts of heat emitted are from the Sahara Desert and the Arabian Peninsula. Cold, blue-colored temperature ranges are found not only at high latitudes, but also in the tropics from cloud tops of thunderstorm systems so extensive that they span thousands of miles. Images like this illustrate one of the most basic stabilizing forces in the Earth's climate system: clear, hot regions lose more energy to space than cold areas.

first time the rate and volume of ice flowing toward the oceans and key discharge points. These results gave scientists a better understanding of long-term change in the polar regions and their role in Earth's climate variations.

In addition, NASA used data collected from the Terra spacecraft to demonstrate the Sun's effects on our planet. Based on Terra's ability to collect data twice each day over the entire planet, researchers were able to gauge the year's heat wave in California.

*Understanding Causes of Variation in Atmospheric Ozone Concentration and Distribution*

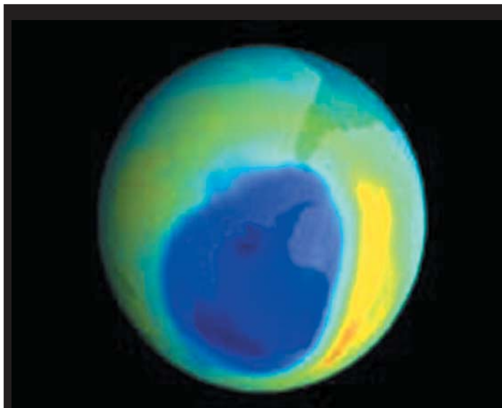
For over 2 decades, NASA has been monitoring changes in the Earth's protective ozone layer, and for the past decade has been observing the chemical processes in the upper atmosphere that lead to those ozone layer changes. Recently, NASA-sponsored researchers showed that climate variability and ozone concentrations are linked in complex ways, and that current directions in climate change may slow the rate of ozone recovery. For example, a collaboration among the United States, Russia, and other nations in flights of scientific instrument-laden aircraft in 2000 over the north polar regions showed that polar stratospheric clouds are closely connected to ozone loss in that region.

In FY 2001, NASA tracked hazardous smoke and smog around the globe using data from the Total Ozone Mapping Spectrometer Earth Probe spacecraft and international field experiments. Early warning of pollution events can help to mitigate their potentially hazardous effects on human health.

In addition, NASA discovered that the "Earth is becoming a greener greenhouse." Using 2 decades of satellite data, NASA researchers determined that plant life in the northern latitudes has grown more vigorously since 1981. This phenomenon could be related to rising temperatures and enriched atmospheric carbon dioxide.

*Atmospheric Chemistry*

In March-April 2001, our understanding of atmospheric chemistry was improved through a successful international field experiment called the Transport and Chemical Evolution over the Pacific airborne campaign. The primary mission objectives were to understand the atmospheric plume flowing out of East Asia, the



**NASA identifies long-term ozone changes**

After reaching a record-breaking size in mid-September 2000*, the ozone hole over Antarctica has made a surprisingly hasty retreat, disappearing completely by November 19, 2000. While the hole changes in size with the seasons, it typically lasts well into December.

Do these two different observations mean the ozone hole is worsening or improving? According to NASA scientists, neither conclusion can be supported by year-to-year changes alone. To answer such questions, NASA accumulates and interprets vast amounts of data and generates predictions of how Earth will change over the coming decades, even centuries.

* This can be seen by the contrast between the blues on the image, which indicate low ozone concentrations, and the yellows and reds, which indicate high ozone concentrations.

way it changes as it moves eastward over the Pacific Ocean, and its contribution to global atmospheric chemical composition. To conduct this research, scientists combined data collected by two specially equipped NASA airplanes flying near Hong Kong and Japan with satellite and ground station measurements taken over the 45-day campaign. By studying the seasonal airflow from Asia across the Pacific, researchers gained insight into the way natural and human-induced changes originating in one continent affect the air quality and climate in another.

*Natural Hazards, Processes, and Mitigation Strategies Identification*

We are sponsoring scientific studies to explore the nature and processes of the Earth's dynamic interior and crust to better prepare for natural hazards such as earthquakes. Explored issues include the dynamics of the Earth's interior and crust, tectonic motions, earthquakes, volcanic eruptions, and the evolution of landscapes. We work together with disaster management experts at the international, Federal, State, and local levels to better understand natural hazards, characterizing natural disasters, and monitoring conditions that may lead to such events.

Both space-based and airborne platforms monitor and assess impacts of natural hazards such as volcanoes, earthquakes, forest fires, hurricanes, floods, and droughts. The short-term benefits are to assess impacts of these events on national and international agriculture, food production, water resources, commerce, and other endeavors. The long-term objective is to develop reliable predictive capabilities.

In FY 2001, NASA improved the ability to understand earthquakes and to predict landslides and volcanic eruptions through space-based observations, by completing the installation of the Southern California Integrated Global Positioning Satellite Network. This was an interagency collaboration for which NASA was the lead implementing organization. The network contains 250 satellite receivers that provide millimeter scale measurement of the crustal deformation in Southern California. The network is moving toward ever more rapid data collection and processing at the millimeter level. In addition, Shuttle Radar Topography Mission data provided

**NASA studies the Earth to predict natural hazards**

This dramatic view looks west along the Cucharas River Canyon in Colorado toward the 13,623 ft high Spanish Peaks, in the foothills of the Sangre De Cristo Mountains. The Peaks are the remnants of a 20-million year old volcano. Rising 7,000 ft above the plains to the east, these igneous rock formations with intrusions of eroded sedimentary rock historically served as guiding landmarks for travelers on the Mountain Branch of the Santa Fe Trail.

Elevation data used in this image was acquired by the Shuttle Radar Topography Mission aboard the Space Shuttle Endeavour. The mission was designed to collect three-dimensional measurements of the Earth's surface. The mission is a cooperative project between NASA, the National Imagery and Mapping Agency of the U.S. Department of Defense and the German and Italian space agencies.

detailed maps of terrain features, improved models for assessing earthquake hazard, and achieved an 80-percent improvement in current elevation maps. The National Imagery and Mapping Administration shared major portions of the mission cost because the data on poorly mapped regions of the Earth is valuable information to the U.S. national security community. U.S. data are now available to researchers for scientific study. These and other space- and ground-based observing systems will greatly enhance the ability to model earthquakes and identify potential vulnerable spots.

### Challenges

A fundamental characteristic of research and development is the difficulty in accurately forecasting progress and results in the short term. Sometimes, new Earth observing technologies take longer than expected to develop or researchers encounter unforeseen problems in analyzing new types of data. In FY 2001, we experienced several such challenges. The launch of the Aqua satellite was delayed because of technical problems encountered during the integration and testing stage of the satellite. This prevented us from achieving several indicators in FY 2001, though we were able to partially achieve our science objectives with secondary data sources. The Jason launch was postponed due to problems with the French-built spacecraft. Similarly, Russian launch delays and problems with a NASA-built instrument delayed the launch of the Stratospheric Aerosol and Gas Experiment-III. However, data from the aging Topography Experiment Poseidon satellite compensated for the Jason delay and Stratospheric Aerosol and Gas Experiment-II data from the now 17-year-old spacecraft were used to offset the Stratospheric Aerosol and Gas Experiment-III delay. Processing of the data obtained by the Measurement of Pollution in the Troposphere instrument provided by Canada were delayed for several months until researchers were able to fix a problem.

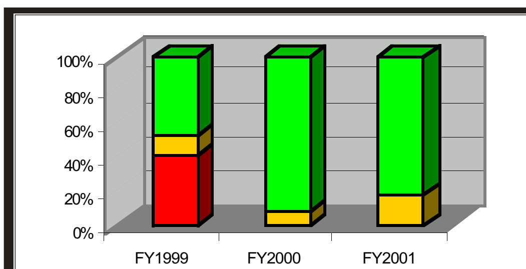
### Assessments

We achieved 9 of the 11 FY 2001 annual performance goals. The following table illustrates the goals that were achieved towards increasing scientific understanding and explaining the dynamics of Earth's global carbon cycle, global water cycle, long-term climate variability, atmospheric composition, and the planet's interior and crust (green). We failed to meet two goals to develop, have ready for launch, and operate instruments on at least two spacecraft within 10 percent of schedule (yellow) primarily due to launch delays explained above. It should be noted that while these goals were not achieved, the yellow rating indicates that progress was significant and achievement is anticipated within the next fiscal year.

| Strategic Goal 1. Expand scientific knowledge by characterizing the Earth system | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 1Y1 | The Earth Science Enterprise (ESE) will successfully develop, have ready for launch, and operate instruments on at least two spacecraft within 10 percent of their schedules and budget to enable Earth Science research and applications goals and objectives. | ● |
| 1Y3 | 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. | ● |
| 1Y4 | Explain the dynamics of global carbon cycle by building improved models and prediction capabilities and meeting 2 of 2 meeting 2 of 2 performance indicators in this research area. | ● |
| 1Y5 | 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. | ● |
| 1Y6 | 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. | ● |
| 1Y7 | 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. | ● |
| 1Y8 | 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 area. | ● |
| 1Y9 | 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. | ● |
| 1Y10 | 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. | ● |
| 1Y11 | 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. | ● |
| 1Y12 | 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. | ● |

## Trends

Overall FY 2001 annual performance goal achievement in expanding scientific knowledge by characterizing the Earth system was 82 percent (green). This represents a decrease from FY 2000, when 93 percent of the goals were achieved, and an increase from FY 1999, when there was a 47-percent achievement.




Overall annual performance goal achievement decreased slightly in FY 2001 to 82 percent, compared to 93 percent in FY 2000.

## Strategic Goal 2. Disseminate Information About the Earth System

The Earth Observing System Data and Information System is the primary driver for this strategic goal. The system manages data and information resulting from NASA's past and current Earth science research satellites and field measurement programs by providing processing, archiving, distribution, and information management services.

### Achievements

The Earth Observing System Data and Information System acquires observations from the network of Earth science satellites and transmits to ground stations around the globe that provide initial processing, and then distributes to a variety of several archival, processing, and distribution centers in the system's network. These observations are refined into a form conducive to scientific research and practical applications and then distributed to end users. This system will be fully developed by the end of 2002. The utility of the system's network has already been proven through its capacity to manage about a terabyte of data and information per day and to serve millions of users per month.

In FY 2001, the system was used to distribute approximately 1.2 million data products per month (exceeding our goal of 450,000) to approximately 150,000 users per month (exceeding our goal of 125,000). The median delivery time for orders was reduced to less than 1 day. Preliminary responses from the user survey indicate that users are satisfied with our service.

### Challenges

While providing unprecedented access to Earth science data, NASA faced several development challenges. Creating uniformity within the diverse network of data centers has been difficult. For example, Centers were using a variety of customer satisfaction forms, making it difficult to evaluate overall network effectiveness. This challenge is being overcome with the implementation of a comprehensive user survey as recommended by the NASA Advisory Committee. Delayed satellite launches and instrument malfunctions have delayed data acquisition and resulted in processing difficulties for some users.

### Assessments

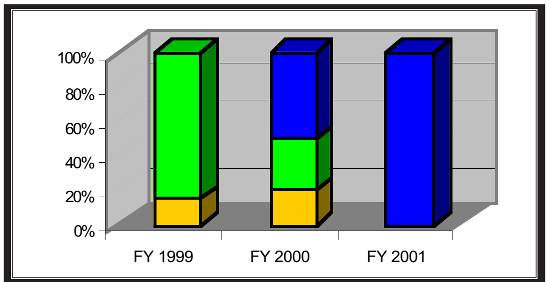
We significantly exceeded the annual performance goals for acquiring, processing, and disseminating information about the Earth system in FY 2001. The comprehensive data and information that we make available to researchers around the world in a timely manner, for free or at marginal cost, enables previously unachievable research that will lead to a better understanding of the Earth system.

**Strategic Goal 2. Disseminate information about the Earth system**

| APG | Description | Assessment |
|---|---|---|
| 1Y2 | Successfully disseminate Earth Science data to enable our science research and applications goals and objectives by meeting all performance indicators in this research area. | |

Trends

We significantly exceeded the FY 2001 performance goal for disseminating Earth system information. The result is a blue rating for better than 100 percent achievement. Our performance in this area also exceeded previous years.




Overall annual performance goal achievement increased to 100 percent in FY 2001, compared to 80 percent in FY 2000.

**Strategic Goal 3. Enable the Productive Use of Earth Science Enterprise (ESE) Science and Technology in the Public and Private Sectors**

Enabling the productive use of science and technology in the public and private sectors includes providing regional decision makers with new products and tools, improving access to remotely sensed data and processing technology, stimulating the development of a robust commercial remote sensing industry, providing remote sensing tools to enable efficiencies in food and fiber production, and increasing public understanding of Earth system science through education.

Achievements

This goal encompasses four key objectives: 1) Develop and transfer advanced remote sensing technology; 2) Extend the use of Earth science research to national, state, and local applications; 3) Support the development of a robust commercial remote sensing industry; 4) Make major scientific contributions to national and international environmental assessments.

The following sections describe FY 2001 achievements.

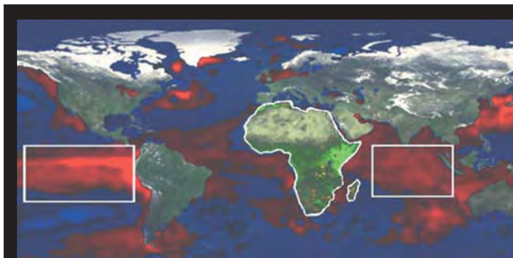
*Remote Sensing Technologies*

A breakthrough in climate modeling was announced in July 2001. Using the newly developed 512-node Silicon Graphic supercomputer, NASA researchers were able to simulate more than 900 days of the Earth's climate in 1 day of computer time. Previous capability was limited to simulating only 70 days of the Earth's climate in 1 day of computer time. This supercomputer is of great value for Earth scientists because it enables more accurate climate change computer models using global satellite observation data collected by NASA. For example, in FY 2001, researchers were able to demonstrate experimental seasonal climate predictions using data from multiple satellites. The combination of a faster computer, more accurate climate models, and the use of more global satellite observations will result in more accurate prediction of climate change science for policy makers and economic decisions. Our ultimate goal is to develop the supercomputing capability to integrate all the components of the climate system into a model of the living, breathing Earth.

*International, National, State, and Local Applications*

Because we are addressing questions of societal importance, Earth science research leads to practical applications. NASA works with National, State, and local government entities to help develop remote sensing applications products and to address issues important to them. These include agricultural productivity and natural resources management, as well as urban and regional planning.

In FY 2001, we continued to monitor and predict disease outbreaks early enough to prevent them or reduce their impact on society through a collaborative project with the U.S. Department of Defense. Using near-real-time satellite vegetation measurements and associated climate data sets, including sea surface temperatures and cloud cover, scientists developed the capability to predict emerging Rift Valley Fever epidemics in East Africa several months before an outbreak occurs. Primarily a disease of sheep, cattle, and other animals, Rift Valley Fever can be transmitted to humans by mosquitoes. Outbreaks can be devastating to the farming economies of rural East Africa and can cause significant illness and loss of life. It is hoped that the ability to map such areas of potential fever activity 2 to 5 months before outbreaks occur could permit vaccination of domestic animals and implementation of appropriate mosquito control programs. The U.S. Department of Defense publishes Rift Valley Fever risk maps on its web site and the World Health Organization has used them. In addition, our investigators provided data support to the Walter Reed Army Institute for Research during an outbreak in Saudi Arabia and Yemen. This is an example of how we provide decision makers with scientific and applications products resulting from NASA investments in Earth science and technology.



**NASA helps track disease**

Satellites provide synchronous measurements of ocean temperature and vegetation conditions. These images illustrate the close relationship between ocean temperature (warmer than normal ocean colors are shown in red, cooler than normal temperatures are in blue), rainfall, and their impact on land vegetation (greener than normal vegetation shown in green).

Scientists have discovered that the combination of the warmer than normal water temperatures associated with El Niño and rising sea surface temperatures in the western equatorial Indian Ocean can trigger outbreaks of Rift Valley Fever in East Africa. The two warm pools of water (highlighted in boxes) increase rainfall in wide areas of eastern Africa , which can lead to large-scale outbreaks of the mosquito-borne disease.

In addition, NASA-sponsored researchers used Landsat-7 data to produce more accurate and detailed maps of major cities around the country at the Mid-Atlantic Regional Earth Science Applications Center. This information is useful to urban planners seeking a better understanding of city growth and how rainfall runoff over paved surfaces impacts regional water quality. Moreover, imagery from the Terra satellite was furnished to the Rapid Response Project for tracking and combating wildfires in the Western United States.

We also demonstrated the use of our Earth science and technology data to Government officials by hosting five workshops around the United States. Over 550 decision makers representing nearly every state attended these workshops. A survey conducted during the workshops found that 35 percent of respondents never used satellite data. A follow-up survey after the workshops revealed that the number fell to 20 percent.

In addition, we discovered that hazardous bacteria and fungi might be crossing the Atlantic by way of dust plumes from Northern Africa and causing human health problems in the U.S. Virgin Islands and Florida. NASA and U.S. Geological Survey researchers analyzed satellite data and field measurements to come to this conclusion.

Another research study dealt with aerosols (small liquid droplets or particles in the air) and coastal ocean characteristics along the U.S. East Coast. The Chesapeake Lighthouse and Aircraft Measurements for Satellites campaign used data from multiple sources (space, air, and water-based) to improve the estimates of aerosols and coastal ocean characteristics.

*Commercial Remote Sensing Industry*

We are committed to increasing our involvement with the commercial remote sensing industry to enhance the utility of Earth Science information in the U.S. economy. Commercial firms are both potential sources of science-quality remote sensing data, and producers of value-added information products from U.S. research satellites.

In FY 2001, we entered into a commercial partnership that will place advanced Global Positioning Satellite technologies in tractors, giving American farmers access to precision farming technologies. NASA and NavCom Technology, Inc., will help farmers use this tool to navigate fields in poor weather or at night. In a partnership with the U.S. Department of Agriculture and four growers associations representing 100,000 American farmers, we are demonstrating new technologies to improve efficiency of agricultural production and reducing risks to crop health. Working with the Federal Aviation Administration and a commercial firm, we demonstrated the use of remote sensing of the terrain around airports to assure compliance with aviation safety guidelines. These are a few examples of the many innovative applications NASA demonstrated in partnerships with service provider organizations.

*Education and Outreach*

NASA's missions and research programs make a unique contribution to education and the public understanding of Earth science. They provide a steady return of discoveries and new knowledge that contributes to the accomplishment of this objective. In FY 2001, we continued to sponsor more than 140 fellowship research awards through NASA's Earth System Science Fellowship program. More than 400 workshops were held to train over 8,600 teachers in Earth science and in the use of NASA Earth science data products to enhance their work with students.

Challenges

NASA applications of Earth science and technology most often involve partnerships with other government agencies or with the private sector. This interface, at times, creates challenges. In terms of commercialization efforts, one plan to use data from a commercial entity was not realized because of a commercial satellite launch failure. The taxpayer's investment in the Quick Total Ozone Mapping Spectrometer satellite was also lost in the same launch failure. That event, coupled with the delayed launch of a separate commercial satellite from which we planned to purchase data, prevented the achievement of several indicators. Another challenge was privatizing a university-based Regional Earth Science Application Center. But, instead of privatizing the center, a commercial spinoff was successfully created.

## Assessments

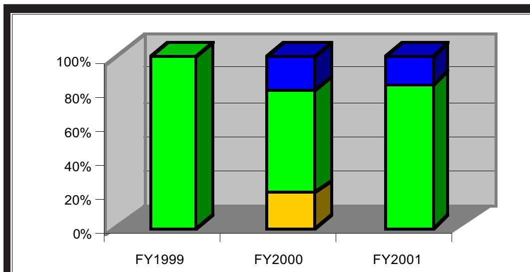
All six goals for FY 2001 were successfully achieved. As the table shows, the goal to achieve success with timely development and infusion of technologies to enable future science missions significantly exceeded our performance goal (blue).

**Strategic Goal 3. Enable the productive use of Earth Science Enterprise (ESE) science and technology in the public and private sectors**

| APG | Description | Assessment |
|---|---|---|
| 1Y13 | 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. | ● |
| 1Y14 | Provide regional decision-makers with scientific and applications products/tools by meeting at least 7 of 8 performance indicators for this applications research area. | ● |
| 1Y15 | Improve access to and understanding of remotely sensed data and processing technology by meeting 3 of 3 performance indicators. | ● |
| 1Y16 | Stimulate the development of a robust commercial remote sensing industry by meeting at least 4 of 5 performance indicators. | ● |
| 1Y17 | Provide remote sensing tools and capabilities that could enable efficiencies in food and fiber production with the aid of remote sensing by meeting the performance indicator in this area. | ● |
| 1Y18 | Increase public understanding of Earth system science through formal and informal education by meeting at least 3 of 4 annual performance goals in this area. | ● |

## Trends

Overall FY 2001 annual goal achievement in enabling the productive use of NASA Earth science and technology in the public and private sectors was better than 100 percent (blue and green combined). This represents an increase from FY 2000, when 80 percent of the annual performance goals were achieved, and FY 1999, when 100 percent of the goals were achieved (green), but none exceeded.




Overall annual performance goal achievement increased to 100 percent in FY 2001, compared to 80 percent in FY 2000.

## Awards, Honors, and Distinctions

One of NASA's top priorities is getting data and technologies to people who need them. In FY 2001, we received numerous distinctions for this effort. NASA Earth science data and visualizations appeared on national and international television and print media reaching millions of people around the world. In fact, approximately 20 articles appear each day on NASA Earth science and technology-related activities in U.S. print media alone. Individual NASA scientists also proved themselves to be leaders in their respective fields. For example, a NASA scientist at the Goddard Institute for Space Studies received the prestigious Heinz Award for work on global climate change. Other NASA scientists and NASA-funded researchers had their work highlighted in countless articles and references in such popular publications as *Nature* and *Science* magazines, as well as discipline-specific publications such as the *Geophysical Research Letters*, the *Bulletin of American Meteorological Society*, and remote sensing journals.

**NASA scientist receives Heinz Award**

Dr. Jim Hansen (rear, second from left), Chief of the Goddard Institute for Space Studies in New York, N.Y., was one of this year's recipients of a $250,000 Heinz Award. The award, bestowed annually by the Heinz Family Foundation since 1993, is given in recognition of people who enhance the lives of others.

The Heinz Award cited Dr. Hansen "for his exemplary leadership in the critical and often-contentious debate over the threat of global climate change." Dr. Hansen accepted the award saying, "I hope that this will encourage other scientists to speak their mind about scientific matters of concern to the public."

Photo Credit: Lynn Keefe

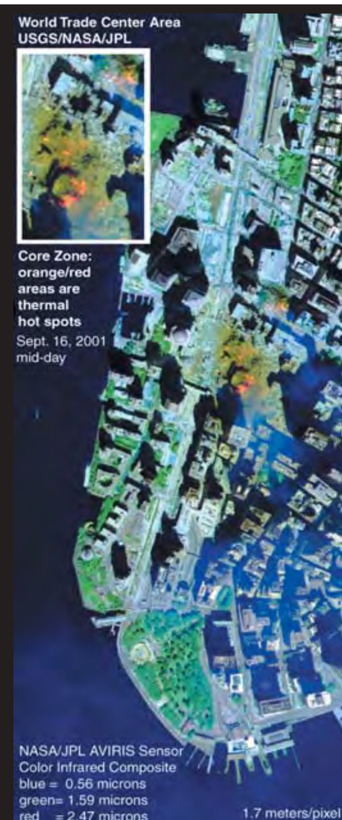
## Partnerships

We clearly recognize the value of partnerships in which each partner can benefit from the knowledge and skills, or competitive advantage, of the others. Significant progress was made through collaboration with other Federal agencies, international partners, and universities. Some examples include:

- NASA is the largest contributing partner to the U.S. Global Change Research Program, a multi-agency endeavor to understand the causes, extent, and consequences of climate change. NASA and the National Oceanic and Atmospheric Administration are partners in the U.S. Weather Research Program, which works to improve routine weather forecasting. The National Oceanic and Atmospheric Administration recently began using NASA's ocean winds and tropical rainfall data to improve its marine weather and short-term climate forecasts.
- Mitigating disasters and encouraging preparedness, including mapping potential earthquake sites through a partnership established with the Federal Emergency Management Agency for this purpose. Towards mitigation and preparedness, three flood basins were selected to demonstrate the benefits of NASA remote sensing technology in producing highly accurate flood hazard maps.
- Developing and launching the latest generation of American weather satellites in partnership with the National Oceanic and Atmospheric Administration. Using funds appropriated to its partner, NASA managed the successful development of the Geostationary Operational Environmental Satellite-M satellite, which was safely launched into orbit.

- Launching the Fourth Convection and Moisture Experiment in August 2001. The field campaign was a complex space, air, and sea effort designed to study how hurricanes are born, how they choose the course they take, and how their tremendous power transports water and energy into the atmosphere. The mission combined the resources of five NASA Centers, the National Oceanic and Atmospheric Administration, the U.S. Air Force, and 80 university researchers.
- Producing the first-ever global map of air pollution in partnership with the Canadian Space Agency. Using data from the Terra satellite, policymakers and scientists now have a way to identify major sources of air pollution and can closely track movement of the pollution anywhere around the globe.

**NASA and the Federal Emergency Management Agency partner in disaster efforts**




NASA sent a scientist to New York, NY, following the events of September 11, 2001, to aid the Federal Emergency Management Agency in the disaster recovery efforts. Using advanced technologies developed for observations of Earth, we provided imagery to emergency managers to help identify dangerous areas of the site and determine the material composition of the wreckage.

NASA's strongest asset was the ability to communicate with the disaster response community, determine the information-product requirements, and translate those requirements into technical specifications that could be met by commercial or other government-agency providers.The above image shows hot spots observed on September 16, 2001. Hot spots are displayed as red and yellow areas.

- Providing a detailed mosaic of the Central American region to a commission of regional government officials wishing to study the Mesoamerican Biological Corridor. Through the cooperative international agreement, the mosaic will be used as a baseline map of the region to allow policymakers and scientists to study life zones, land use, geological structure, hydrology, and other ecological factors over the coming years. The effort is in direct support of an accord signed by the U.S. Secretary of State and Central American foreign ministers in early June 2001.
- Detailing the affect of the Hawaiian Islands on thousands of miles of ocean and winds. In a *Science* magazine paper, scientists at NASA and their colleagues at the University of Hawaii discussed how the wake of the islands affects the atmosphere and Pacific Ocean.

# Biological and Physical Research

*NASA's biological and physical research mission is to use the synergy among physical, chemical, and biological research in space to acquire fundamental knowledge and generate space travel and Earth applications. Once humans took the first steps off Earth and into space, we entered into a new realm of opportunity to explore profound questions, new and old, about the laws of nature. At the same time, we entered an environment unique in our evolutionary history that poses serious physiological and psychological challenges. NASA's biological and physical research addresses the opportunities and challenges of space flight through basic and applied research on the ground and in space. NASA seeks to exploit the rich opportunities of space flight for fundamental research and commercial development, while conducting additional research to enable efficient and effective systems for protecting and sustaining humans in space.*

# Biological and Physical Research

## Strategic Goals

NASA's biological and physical research pursued the following five strategic goals in FY 2001:

1. Expand the space frontier
2. Expand scientific knowledge
3. Enable and establish a permanent and productive human presence in Earth orbit
4. Expand the commercial development of space
5. Share the experience and discovery of human space flight

### Strategic Goal 1. Expand the Space Frontier

NASA conducts robotic space missions to collect data and prepare for future human exploration missions that will expand the space frontier.

#### Assessments

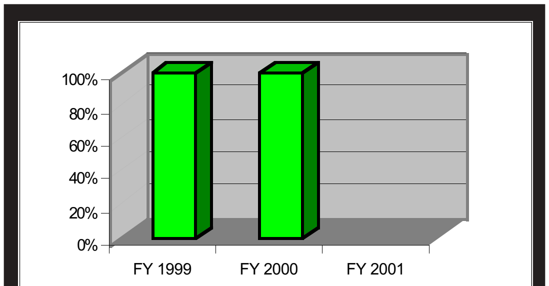
The annual performance goal relating to biological and physical research was rendered no longer applicable. We successfully completed the testing and delivery of a radiation monitoring experiment when the Lander portion of the Mars Surveyor Mission was cancelled due to cost and technical considerations related to the Lander. After mission cancellation, work was halted following the final testing of the hardware for a second experiment that would have analyzed Martian dust and soil, as well as an experiment on producing propellants from the Martian atmosphere. This hardware is in bonded storage and may be flown on later missions.

**Strategic Goal 1. Expand the space frontier**

| APG | Description | Assessment |
|---|---|---|
| 1H1 | Complete testing and delivery of experiments for spacecraft integration for the Mars Surveyor Program 2001 orbiter and lander missions. | N/A |

#### Trends

NASA continues to leverage planned robotic missions to Mars by developing experiments to characterize the radiation and dust environments experienced by these missions. In 2 of the past 3 years, the Agency achieved its biological and physical research goals, supporting the long-term strategic goal of expanding the space frontier; in FY 2001, similar achievement was only precluded by the cancellation of the Lander portion of the mission.




NASA continued to support the strategic goal of expanding the space frontier by developing experiments for planned robotic missions to Mars; only the cancellation of the lander mission itself precluded attainment of this goal in FY 2001.

### Strategic Goal 2. Expand Scientific Knowledge

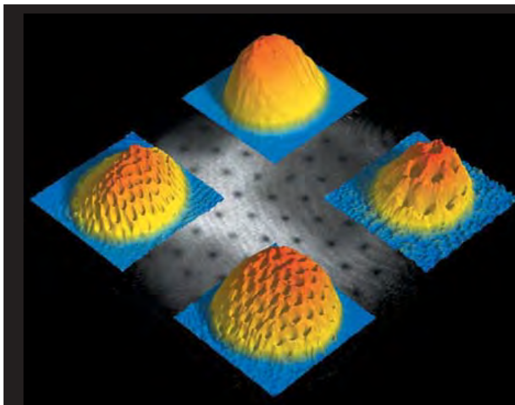
The space environment offers a unique laboratory in which to study biological and physical processes. Researchers take advantage of this environment to conduct experiments in physics, chemistry, and biology in search of answers to basic and applied research questions. A broader program of ground-based research supports research progress in space and develops new hypotheses for testing.

## Achievements

FY 2001 was an exceptional year for NASA's basic physics research. Early in the year, researchers reported that they brought traveling light to a full stop, held it, and then sent it on its way (*Physical Review Letters*, January 29, 2001, Vol. 86, Issue 5). Through Agency funding, researchers developed lasers that bring a beam of light to a complete stop in a specially designed trap, and then release it. This finding could have an important impact on future information technologies.

Another team of NASA scientists created a gas cloud riddled with tiny whirlpools similar to those that cause "starquakes" (*Science*, Vol. 292, No. 5516, April 20, 2001). The researchers used an ultra-cold cloud of sodium gas and quantum effects to create a physical model of phenomena that take place deep inside distant stars. The importance of this kind of low temperature physics research was reinforced at the end of 2001 when NASA-funded researcher Dr. Wolfgang Ketterle was awarded the Nobel Prize in Physics for his seminal work on Bose-Einstein Condensates, a new state of matter in which individual atoms merge into each other.

These experiments represent substantial milestones in physicists' quest to study quantum phenomena (physical phenomena that are ordinarily only observable at microscopic scales) in macroscopic systems. This research could have far-reaching implications for the future of information and communication technologies.



**NASA creates starquakes in the laboratory**

As part of a NASA-funded research project, scientists at the Massachusetts Institute of Technology developed a system to create a space phenomenon that does not occur naturally on Earth. They super-cooled a sodium gas cloud and made it spin, thereby creating multiple whirlpools similar to starquakes that occur in space. Starquakes are phenomena that appear as glitches in the rotation of pulsars in space.

This research may teach scientists more about the history of our universe and the stars within it, and may eventually lead to vast improvements in highly precise atomic clocks.

In biotechnology research, a research group at the Massachusetts Institute of Technology grew heart tissue with "significantly improved" structural and electrophysiological properties, using NASA bioreactor technology (*Journal of Physiology-Heart and Circulatory Physiology*, January 2001). Unlike tissue grown using more conventional technology, the tissue grown in the NASA bioreactor actually beats like native heart tissue. The bioreactor allows researchers to grow tissues in the laboratory that much more faithfully reproduce the properties of natural tissues in the body. These tissues allow researchers to explore mechanisms of disease, test and develop drugs, and may ultimately improve processes for creating engineered tissue for use in treatment and transplant.

## Challenges

NASA planned to conduct research aboard a dedicated research Space Shuttle mission (STS-107) in FY 2001; this mission is now scheduled for FY 2002.

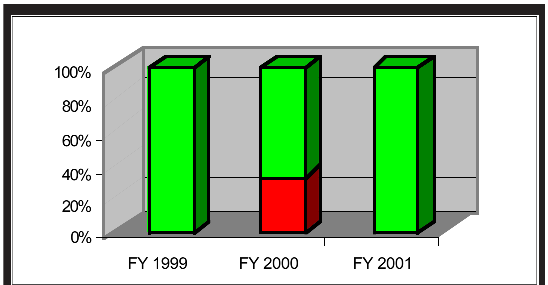
Assessments

We achieved both FY 2001 biological and physical research goals supporting an expanded, productive research community and continuing International Space Station initial research with 6 investigations.

| Strategic Goal 2. Expand scientific knowledge | | |
|---|---|---|
| APG | Description | Assessment |
| 1H3 | Support an expanded, productive research community to include 975 investigations by 2001 | Green |
| 1H4 | Conduct outstanding peer-reviewed and commercial research on STS-107 to advance knowledge in the fields of medicine, biology, biotechnology, fluid physics, materials processing, and combustion | Yellow |
| 1H5 | Continue initial research on the International Space Station by conducting 6 to 10 investigations | Green |

Trends

NASA met 100 percent of its annual performance goals related to biological and physical research under this strategic goal in FY 1999, 67 percent in FY 2000, and 67 percent in FY 2001. Performance goals not achieved in FY 2000 and FY 2001 are related to technical and schedule difficulties with flight platforms. As noted above, the strength of the biological and physical research community continues to grow.




NASA maintained the record of success in attaining annual performance goals that required the establishment of a strong research community.

**Strategic Goal 3. Enable and Establish a Permanent and Productive Human Presence in Earth Orbit**

NASA conducts fundamental and applied research in the biological and physical sciences to reduce the health risks of space travel and to develop technology for efficient, self-sustaining life-support systems.

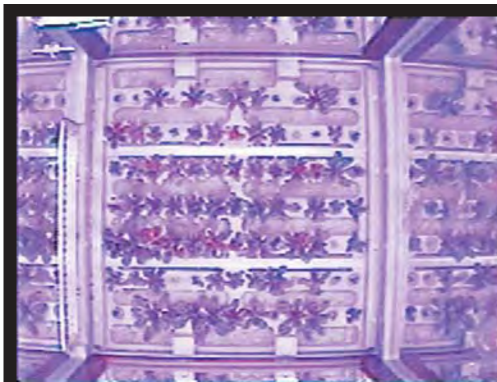
Achievements

Outfitting the International Space Station for research began with the delivery of the Human Research Facility in March 2001. NASA delivered two research equipment racks in mid-April and an additional two at the beginning of Expedition 3 in August. The Agency is on track to deliver yet another five research equipment racks by the end of 2002. Despite underestimation of Station maintenance requirements and a greater-than-expected volume of "off-normal" activities during Expeditions 1 and 2, the Space Station team was able to meet the minimum research objectives of these increments.

*Experiments Conducted*

The Expedition 1 crew initiated a small number of U.S. research activities, including crew Earth observations, the educational Space Exposed Experiment Developed for Students (plant growth in microgravity), biological crystal growth (structural biology), space technology motion and vibration experiments, and human research baseline data collection.

With Expedition 2 completed in July, the research program on the Space Station was underway. The team conducted 18 experiments. The Expedition focus was on biomedical research and included studies of biological effects of space radiation, characterization of the Space Station radiation environment, bone loss and spinal cord response during space flight, and interpersonal influences on crew member and crew ground interactions.



**NASA studies plant growth in space**

This June 7 image shows *Arabidopsis thalinia*, a member of the cabbage and radish family, after 28 days of growth aboard the International Space Station. The seedlings were germinated and are growing inside the Advanced Astroculture built by the Wisconsin Center for Space Automation and Robotics at the University of Wisconsin-Madison. Scientists selected this plant for flight because it is used as a model for understanding plant biology. It grows rapidly, producing seeds in about 6 weeks, and can be cultivated in restricted space.

Research on Expedition 3 includes 8 new and 10 continuing experiments. New experiments include investigation of the mechanism of space flight-induced orthostatic intolerance, a condition that can make standing or walking impossible for astronauts returning to Earth; a study of pulmonary (lung) function in space as affected by extravehicular activities; a study of the risk factors associated with kidney stone formation during and after space flight; new techniques for structural biology in space; and a study of materials passively exposed to the space environment around the Space Station to better define changes in material properties and on-orbit degradation trends.

NASA's Physics of Colloids in Space experiment is already yielding unique new data on never-before-seen crystallization patterns. The experiment takes advantage of reduced gravity to study the processes by which crystals form. This basic research may lead to improved devices for using light in computer and communications applications.

**NASA studies colloids in space**

One of the first images from the Experiment of Physics of Colloids in Space on the International Space Station, a sample was illuminated with white light to produce the image. The colored regions result from refraction of the white light by the sample cell, splitting it into its component colors. The way the light scatters reveals the placement of particles suspended inside fluid in the test cell.

A colloidal suspension consists of fine particles in a fluid matrix. Paint, ink, and milk are all examples of colloidal suspensions. Within colloidal suspensions, crystals with unique properties can form and affect the properties of light passing through them. Someday colloids may form the basis of new classes of light and fiber optic switches, filters, and displays that can fuel the evolution of next-generation computer and communication technologies.

*Research Findings*

FY 2001 International Space Station research results will be reported as data are collected and analyzed. Results reported in FY 2001, based on earlier research missions and ground-based experiments, support continued progress in understanding and controlling the negative effects of space travel.


**NASA astronauts adapt to their upside-down world, but their cognitive maps may not**

15 February 2001. Five astronauts take a break from Destiny laboratory installation work as they near the end of their several days' visit aboard the International Space Station. Their position might be termed "upside-down" on Earth, but in their weightless environment, the arrangement eliminates gravitational complications like blood rushing to the head. However, NASA research published in FY 2001 shows that their cognitive maps may not adapt so easily to their new environment.

Findings published in 2001 based on earlier space-based research suggest that the human mind contains an internal model of gravity and that this model may be very difficult or even impossible to dislodge. Astronauts adjust quickly to the many challenges of orientation and movement associated with space flight, but new results suggest there may be limits to this adaptability. When astronauts attempted to catch a "falling" object moving at a constant speed in reduced gravity, they could not adjust their behavior to correctly respond to the fact that objects do not "fall" increasingly faster in space. The expectation that a falling object accelerates proved impossible to unlearn over the course of the experiment. This experiment raises the possibility that the nervous system may contain a hardwired model of gravity. If confirmed, this would be a fundamental discovery that could influence medical treatments for people with damaged or impaired nervous systems. In addition, this finding has important implications for the design of safe and efficient environments and systems for human space flight.

NASA investigators tested the drug midodrine as a remedy for the dizziness and fainting (called orthostatic intolerance) that astronauts sometimes experience when attempting to stand immediately after returning from space. The drug proved effective in ground-based test subjects and will be further tested in space. This research is important for ensuring the safety of future space travelers who may need to evacuate a returning spacecraft in an emergency, or operate a spacecraft without assistance after landing on another planet.

In what may be a breakthrough for astronauts and osteoporosis victims alike, researchers were able to prevent bone loss using mild vibrations (*Federation of American Societies of Experimental Biology Journal*, October 2001). Normally, rats lose bone when their hind legs are supported so that they do not bear the weight of the body. NASA researchers were able to counteract this bone loss by exposing the rats to mild vibrations. This study opens the door to a new method for controlling the loss of bone that astronauts experience in space at a rate of 1 percent per month; and planned clinical studies will determine the usefulness of vibration for treating or preventing osteoporosis on Earth.

## Challenges

Fiscal Year 2001 is the first year of a broad transition from a focus on the Space Shuttle to a focus on the International Space Station as the primary platform for flight research. Major efforts to restructure Space Station research were initiated. These efforts responded to substantial reductions in available budgets for research equipment and facilities, support, and operations. In addition, NASA is addressing potential reductions in available crew time for research. While this restructuring is of central importance for the future of Space Station research, it did not materially affect resources necessary for executing the Agency's planned research program in FY 2001. Despite underestimation of Station maintenance requirements and a greater-than-expected volume of "off-normal" activities during Expeditions 1 and 2, the Space Station team was able to meet the minimum research objectives.

## Assessments

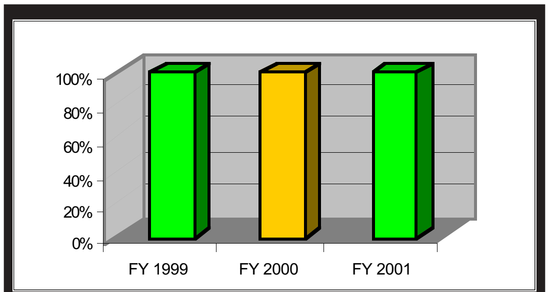
All four FY 2001 annual performance goals were achieved (green). As the table below illustrates, we were successful in developing new biomedical and technological capabilities for living in space. We successfully demonstrated technologies to reduce Space Station baseline life support logistics by up to 25 percent, and successfully initiated the Bioastronautics Initiative by starting a NASA/National Cancer Institute collaboration and conducting a peer review of the National Space Biomedical Research Institute.

**Strategic Goal 3. Enable and establish a permanent and productive human presence in Earth orbit**

| APG | Description | Assessment |
|---|---|---|
| 1H17 | Develop new biomedical and technological capabilities to facilitate living and working in space and return to Earth. | ● (green) |
| 1H18 | Demonstrate, in ground test, at least one technology that could reduce up to 25 percent of life support logistics over International Space Station (ISS) baseline and release report of progress for review on the Internet. | ● (green) |
| 1H31 | Initiate implementation of the Bioastronautics Initiative by beginning a NASA/ National Cancer Institute (NCI) collaboration and conducting a peer review of the National Space Biomedical Research Institute. | ● (green) |
| 1H29 | Improve the health of the NASA workforce. | ● (green) |

Trends

NASA met 100 percent of its biological and physical research goals in support of this strategic goal in FY 1999 and FY 2001.



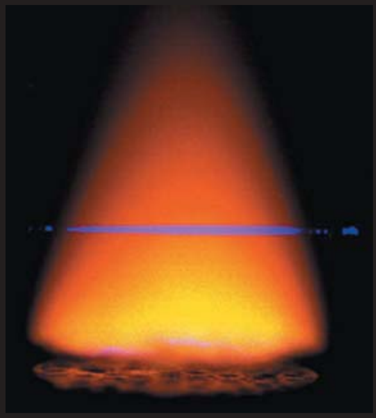

NASA increased the strategic goal of establishing a permanent and productive human presence in Earth orbit with 100 percent (green) FY 2001 goals achieved, an improvement over FY 2000's performance.

**Strategic Goal 4. Expand the Commercial Development of Space**

NASA provides knowledge, policy, and technical support to facilitate industry investment in space research, and enables commercial researchers to take advantage of space flight opportunities for proprietary research.

Achievements

Growth in the numbers of commercial partners participating in the program continued in FY 2001, and an initial set of six commercial experiments was conducted aboard the Space Station. StelSys, a commercial research firm, signed an agreement with NASA to explore commercial applications of bioreactor technology research, specifically in areas related to biological systems. Bristol-Myers Squibb and the Center for BioServe Space Technologies successfully demonstrated that production of antibiotics is substantially greater in microgravity than on the ground (Monorden at 200 percent, Actinomycin D at 75 percent), and they are working to apply this research to ground-based processes. The Center for Commercial Applications of Combustion in Space at the Colorado School of Mines established an agreement to work with Sulzer Orthopedics Biologics and other partners on the development of a ceramic-metal composite that may lead to more durable materials.



**NASA studies combustion in microgravity**

The Earth's gravity has well-known effects on combustion processes, among which are those arising from buoyancy and convection. In many experiments, these effects dominate the fundamental combustion processes so that the latter are difficult if not impossible to study. By conducting combustion experiments in near zero gravity, the masking effects caused by convection can be minimized and new fundamental design-related knowledge can be gained. This knowledge can be used in models to develop new and better combustion-related products and processes to be produced either in space or on Earth.

The Center for Commercial Applications of Combustion in Space is a NASA/industry/university space commercialization center based at the Colorado School of Mines in Golden, Colorado, which conducts research that can benefit from the unique properties of space.

Challenges

Commercial interest in space research is contingent on continuing, reliable, and predictable access to space for commercial experiments. While commercial research is well positioned to respond to changes in resource availability, frequent access to space remains the highest challenge.

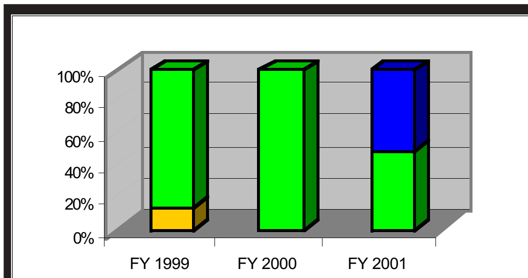
Assessments

FY 2001 included continued growth in the number of commercial partners and an initial set of 6 experiments conducted aboard the International Space Station. Both annual performance goals were achieved as shown in the table below.

| Strategic Goal 4. Expand the commercial development of space | | |
|---|---|---|
| APG | Description | Assessment |
| 1H22 | Establish at least ten new, active industrial partnerships to research tomorrow's space products and improve industrial processes through NASA's Commercial Centers, and find opportunities for space experiments. | Blue |
| 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. | Green |

Trends

NASA continues to accomplish 100 percent of its biological and physical research goals in support of its strategic goal to expand the commercial development of space.



NASA continues to achieve annual performance goals for enabling and promoting commercial research in space.

**Strategic Goal 5. Share the Experience and Discovery of Human Space Flight**

NASA seeks to use its research activities to encourage educational excellence and to improve scientific literacy from primary school through the university level and beyond. The Agency delivers value to the American people by facilitating access to the experience and excitement of space research, and by striving to involve society as a whole in the transformations brought about by research in space.

Achievements

During FY 2001, NASA distributed 10,000 biological and physical research portfolios to the general public and education audiences. These materials explained the new emphasis on multi-disciplinary science, highlighting a variety of scientific accomplishments in the year 2000.

The Agency also held its first interactive education and public outreach broadcast as part of a technically-oriented Pan Pacific Microgravity Workshop. A morning session linked school classes located at California Science Center, Los Angeles; Columbus Science Institute, Ohio; Louisville Science Center, Kentucky; and the Liberty Science Center, New Jersey. An afternoon interactive broadcast translated an array of technical topics for members of the general public, linking audiences at the California Science Center, Bishop Science Center, Hawaii, and Flinders University, Australia.

In addition, NASA revamped its biological and physical research material on the World Wide Web to reflect the enterprise's new status and mission, and to group material specifically focused for public, education, and technical audiences. The Agency received requests for, and distributed, over 4,000 interactive CDs explaining space flight and space research to the layman and educator as a result of its electric light tower exhibit touring the country. In collaboration with the U.S. Air Force Academy Department of Biology, NASA completed development of an undergraduate-level course in space biology. Speakers and exhibits participated in at least 19 public and educational national conventions, in addition to numerous industrial conferences, and NASA community open houses.

**NASA helps high school teachers prepare students to participate in space research**

The International Space Station is not only a useful tool for research, but also a valuable educational tool. In the past year, high school students participated in preparing and loading samples of protein crystal solutions that will go into space. Protein crystal growth experiments may one day lead to improved drug design and treatment of disease. In addition, the program exposed the students to real-world science, and enabled them to learn how to conduct such advanced, seemingly esoteric research.

## Challenges

NASA continues to face the difficult challenge of highlighting and explaining the scientific and technical content of Space Station research. The Agency's external advisory committees continue to encourage NASA to find new means of bringing the excitement of space research to the general public.

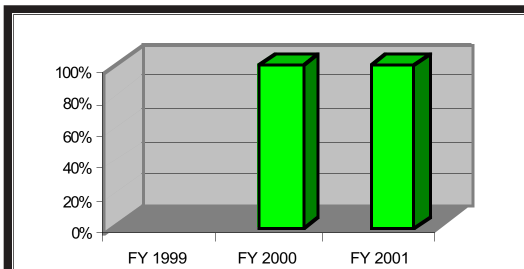
## Assessments

We achieved this biological and physical research goal in FY 2001. As the table shows, we supported participation in human exploration and development of space research through general public and education outreach efforts.

| Strategic Goal 5. Share the experience and discovery of human space flight | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 1H26 | Support participation in Human Exploration and Development of Space (HEDS) research. | ● |

## Trends

In both FY 2000 and FY 2001, the Agency achieved 100 percent of its biological and physical research goals in support of its strategic goal to share the experience and discovery of human space flight.




NASA continues the previously established precedent of success in sharing the experience and discoveries of space flight with everyone.

## Awards, Honors, and Distinctions

The excellent work of the NASA's biological and physical research has been recognized in a number of ways. The most notable is the award of the 2001 Nobel Prize in Physics "for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensate." Dr. Wolfgang Ketterle, professor at the Massachusetts Institute of Technology and one of three recipients of the award, won for his NASA-funded work on the Bose-Einstein Condensates, a new state of matter in which individual atoms merge into each other. The discovery of the Bose-Einstein is "going to bring revolutionary applications in such fields as precision measurement and nanotechnology," according to the citation by the Royal Swedish Academy of Sciences. It adds that the research offers possibilities for studies of fundamental processes involving matter and energy, especially in precision measurements of motionless atoms. "Revolutionary applications of Bose-Einstein appear to be just round the corner," it states.

Photo:

**NASA funds Nobel Prize-winning physics research**

Wolfgang Ketterle (left) of the Massachusetts Institute of Technology shared the 2001 Nobel Prize in Physics with Carl Wieman and Eric Cornell of Joint Institute for Laboratory Astrophysics, an interdisciplinary research center in Boulder, CO, for his work on Bose-Einstein condensates.

The theoretical existence of condensates was first proposed by Albert Einstein in 1924, based on work by Satyendra Nath Bose. This new form of matter, often called the "fifth state," occurs when a group of atoms behaves like a single particle. It was first created in 1995 by Wieman and Cornell by cooling atoms of rubidium to within less than a millionth of a degree of absolute zero. Ketterle's group at the institute managed to make a condensate only months later. In subsequent years, Ketterle's group clarified the properties of aspects of condensates. The timeline from Einstein to Wiegman and Cornell to Ketterle to the condensate research that will continue into the foreseeable future illustrates the long-term view that NASA must maintain in promoting breakthrough discoveries.

## Partnerships

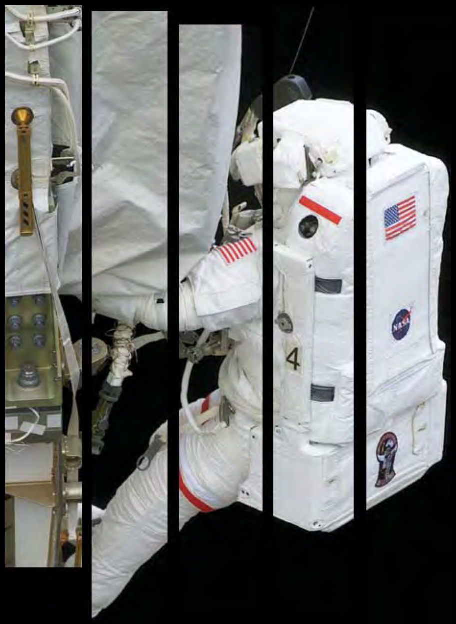
NASA is committed to fair, open, and competitive peer review processes for the selection of scientific research. The Agency seeks to take full advantage of the broader pool of scientific and technical talent at universities, in other Government agencies, and in industry. In addition to regular, open solicitations for investigator-initiated research proposals, NASA pursues its goals through academic consortia, commercial space centers, and memorandums of understanding with other Federal agencies and nongovernmental organizations. Independent experts regularly review investigations, consortia, and commercial centers for merit.

In FY 2001, NASA established a new Memorandum of Understanding with the U.S. Department of Agriculture, conducted a joint research solicitation with the National Cancer Institute, and continued work under 18 other agreements with the National Institutes of Health. The enterprise has 41 active agreements with other Federal agencies.

The International Space Station is among the largest and most complex international cooperative science and technology projects in history. It will include over 25 internal laboratory sites and 25 external sites to support U.S. research and development projects. The U.S. utilization program will involve extensive coordination of U.S. users from academia, industry, and government, as well as close liaison with the programs of our international partners in Canada, Europe, Japan, and Russia. In response to Administration and Congressional direction, NASA has been developing the option for a nongovernmental organization to manage the U.S. utilization of the Space Station. In June 2001, NASA completed an internal study to thoroughly define the scope of functions involved in the Space Station utilization and to prepare for a potential procurement activity. NASA is in the final stages of consultation with the Administration and the U.S. Congress regarding the procurement.

# Human Exploration and Development of Space

*NASA's human exploration and development of space mission is to open the space frontier by exploring, using, and enabling the development of space to expand the human experience into space and bring the benefits of space to Earth. Our mission includes the development of innovative technologies to support our programs and make them available for other applications that provide benefits to the Nation. We will share our knowledge and discoveries with the public to enhance science, mathematics, and technology education and increase the scientific and technological literacy of all Americans.*



# Human Exploration and Development of Space

## Strategic Goals

To achieve this mission, NASA is pursuing four strategic goals:

1. Expand the space frontier
2. Enable and establish a permanent and productive human presence in Earth orbit
3. Expand commercial development of space
4. Share the experience and discovery of human space flight

### Strategic Goal 1. Expand the Space Frontier

NASA believes that the need to expand the frontiers is basic to human beings and integral to the American culture. Today, space is one of the new frontiers being progressively explored. Earth orbit, the Moon, near-Earth space, Mars and the asteroids, the moons of the giant planets of the outer solar system, and more distant worlds represent the endless, ever-expanding frontier of the night sky under which the human species evolved and toward which the human spirit is inevitably drawn.

#### Achievements

Throughout FY 2001, NASA continued to define potential human/robotic exploration architectures and technologies through the efforts of an internal planning team, the Decadal Planning Team, now known as the NASA Exploration Team, which focuses upon science-driven and technology-enabled capabilities for future applications and destinations. These studies have changed the way NASA has approached space exploration. The fundamental strength of the team is the creation of a single cross-enterprise, cross-center vision for this exploration.

To constructively tackle the many technical challenges, the Human Exploration and Development of Space Technology and Commercialization Initiative, funded at a level of $20 million in FY 2001, was initiated following a 6-month program formulation involving numerous NASA Enterprises, Field Centers, universities, and companies. The focus of this initiative was to identify new concepts and develop new technologies to enable the future human/robotic exploration and commercial development of space.

In February 2001, the Technology and Commercialization Initiative issued a Cooperative Agreement Notice, which yielded 152 proposals, from which 43 were recommended for funding in May 2001. The resulting program would have had a total scope of $40 million over 24 months, including $12 million in cost sharing from non-NASA sources. In the spring of 2001, Technology and Commercialization Initiative funds were frozen and in the fall of 2001, the funds were transferred to the International Space Station.

#### Challenges

*Technology Development and Commercialization*

In place of the Technology and Commercialization Initiative as a means of implementing technology research in the near term, NASA continues to foster technology development by cooperative interaction among NASA's Enterprises and Centers.

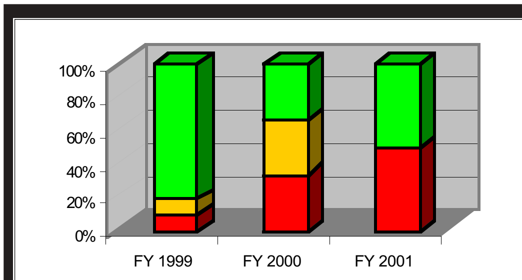
### Assessments

One of two FY 2001 annual achievement goals was achieved (green). We achieved the goal to complete initial next decade planning mission architecture studies and technology plans. The goal to initiate a technology commercialization program was not achieved (red).

| Strategic Goal 1. Expand the space frontier | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 1H1 | Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 missions. | N/A |
| 1H2 | Complete initial next decade planning mission architecture studies and technology plans. | Green |
| 1H32 | Initiate a technology commercialization program and establish a synergistic relationship with industry. | Red |

### Trends

In FY 2001, NASA achieved 50 percent of the annual performance goals (green) associated with this strategic goal. This represents an increase from FY 2000, when 33 percent of the annual performance goals were achieved and a decrease from FY 1999, when 82 percent of the goals were achieved.




NASA's ability to expand the space frontier improved from the previous fiscal year.

## Strategic Goal 2. Enable and Establish a Permanent and Productive Human Presence in Earth Orbit

Despite advances in technology, people continue to be the major factor in the success or failure of most Earth enterprises. In many cases, innovative technologies are most effective when used to enhance the productivity of humans. Moreover, people are an essential 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, the human exploration and development of space enterprise opens the door to an array of benefits, tangible and intangible, for the people of the United States and the world. It is therefore a NASA goal 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.

### Achievements

*Expendable Launch Vehicles*

FY 2001 NASA achievements not associated with specific annual performance goals include seven dedicated Expendable Launch Vehicle launches. The Expendable Launch Vehicle program provides acquisition and technical management of launch services acquired competitively to meet NASA's scientific, technology, and earth observing customer requirements. All NASA launches successfully deployed their payloads in the proper orbit. One NASA payload was manifested as a secondary on a Federal Aviation Administration-licensed commercial mission, which failed to deploy the secondary payload to its desired orbit.

*Space Shuttle Safety Investment Program*

The primary objective of safety upgrades is to achieve major reductions in long-term operational risk. During FY 2001, all flight certification testing of the high-pressure fuel turbopump was accomplished. In addition, system development approval was obtained for the Advanced Health Management System Phase I, External Tank Friction Stir Weld, Main Landing Gear Tire/Wheel Improvement, and the Cockpit Avionics Upgrade Increment I.


**NASA Space Shuttle makes routine landing**

22 August 2001. In this overall view of Houston's Mission Control Center in Texas, the Space Shuttle Discovery is shown on the big screen as it lands at Kennedy Space Center in Florida, marking the end of a successful mission to the International Space Station.

The primary objective of supportability upgrades is to provide replacement systems for those existing systems that are already or becoming obsolete and that will not reliably support Space Shuttle operations through at least 2012. Supportability upgrades primarily mitigate obsolescence issues and potentially enhance performance, reduce processing time, or reduce operations costs. Currently, there are several supportability upgrades in development.

*Space Shuttle Operations*

Seven successful Space Shuttle missions were supported in FY 2001 as planned, with all scheduled Shuttle flights going to the Space Station. FY 2001 began with a banner flight. STS-92 marked the 100th Space Shuttle mission. In April 2001, the Shuttle program celebrated the 20th anniversary of the flight of Columbia, the very first Space Shuttle flight. It was also the inaugural flight of the new Block II engine, which has increased pump robustness for a more reliable, safe engine.

All missions (STS-92, STS-97, STS-98, STS-102, STS-100, STS-104, and STS-105) achieved 100 percent overall success in meeting mission objectives. STS-102 and 105 flights were crew transfer missions. STS-100 delivered the Canadian Space Station Remote Manipulator System, the station's mechanical arm used to perform assembly operations on later flights. STS-104 delivered the Joint Airlock, which provided extravehicular activity capability for Space Station inhabitants.

*On-Orbit Mission Success*

The Space Station made remarkable on-orbit and technical progress during 2001. The year began with the Unity Node, Zarya Functional Cargo Block and Zvezda Service Module operating normally on-orbit. Missions to the Space Station picked up at a rapid pace. Since October 2000, seven Space Shuttle missions and eight Russian Progress and Soyuz vehicle missions were completed to the Station, delivering well in excess of the projected 180,000 pounds of hardware and logistics. Phase II of the program was achieved, providing a fully functional on-orbit operational facility with research capability.

In addition, the first exterior framework truss structure segment and third docking adapter port were delivered in October 2000. Permanent human presence on the station began in November with U.S. Commander Bill Shepherd leading the Expedition 1 crew of Yuri Gidzendo and Sergei Krikalev aboard a Russian Soyuz spacecraft. Two solar power arrays contributing an additional 19 kilowatts of power, batteries, and thermal radiators were added in December.

The heart of the U.S. research and operational control system was deployed in February 2001 with the launch of the U.S. Laboratory Destiny, the first long-term U.S. orbiting lab in over 20 years. Leonardo, the first Italian-built Logistics Module, delivered the first research payload rack to the Station in March, allowing the Expedition 2 crew, also launched in March, to increase research activities while continuing station outfitting. Eighteen different experiments, primarily focused on biomedical research, were initiated during the second expedition. In April, the primary contribution of Canada was deployed, a 60-foot-long state-of-the-art robotic arm, Canadarm 2, which will play a key role in further assembly, operations, and maintenance activities. Rafaello, the second Italian-built Logistics Module, also carried two research payload multipurpose Express Racks to orbit.

The U.S. Airlock Quest was installed in July, enabling the crew to conduct Station-based space walks without the Shuttle present. The Expedition 3 crew, and two additional research payload multipurpose Express Racks were delivered in August, bringing the total research rack number to five. Ten new and eight on-going payloads in the biomedical and microgravity areas continue operations on board. The United States and Russia continued throughout the year to provide logistics resupply with Shuttle outfitting flights, Russian Progress resupply missions, and Soyuz crew vehicle flights. The most recent contribution to what is already the most capable spacecraft ever deployed to orbit was the addition of the Russian Docking Module Pirs on September 17, 2001. This module provides additional docking ports for Progress and Soyuz vehicles, and an airlock for supporting space walks using Russian spacesuits.

**NASA performs first space walk from new airlock**

21 July 2001. Astronaut Michael L. Gernhardt, STS-104 mission specialist, performs the first Space Station extravehicular activity with the International Space Station. During this space walk, Gernhardt and astronaut James F. Reilly attached a nitrogen supply tank to the Airlock Quest's shell and also moved hand-over-hand up the Station's solar array truss to take a look at a gimbaled assembly mechanism that allows the arrays to swivel with the Sun. This space walk was the first ever to make use of the new airlock.

Assembly and operations experiences have demonstrated NASA's ability to integrate the large and complex International Space Station structure on-orbit. To date, over 400,000 pounds of U.S. hardware has been delivered to Kennedy Space Center, with over 125,000 pounds of U.S. hardware launched to orbit over the last year, bringing the total on-orbit weight to over 303,000 pounds. The Prime Contractor vehicle development work is now 98 percent complete. NASA continues on-orbit research preparations, through fabrication and test of five additional research racks that will be on-orbit by the end of 2002, as well as ongoing crew training and development of ground support infrastructure.

*International Space Station Multi-Element Integration Testing*

The Space Station program completed Multi-element Integration Testing Phase 2 for assembly flights 8A-12A during FY 2001. The five-step test configuration was re-planned for accomplishment in a four-step test configuration. Integrated testing for flight element 8A, including the central truss segment, Canadian Mobile Transporter base for the robot arm, and Laboratory emulator, was completed in October 2000. Integrated testing for flight elements 8A and 9A, including the starboard truss segment, S-Band communication system and the electrical power system, was successfully completed in April 2001. Flight elements 8A, 9A, and 11A, including the port truss segment and ultra-high frequency communications system, were completed in May. The integrated testing for flight elements 8A, 9A, 11A, and 12A, including the second port truss segment, was completed in June. Additional regression and standalone testing will be completed throughout 2002. Multi-element Integration Testing Phase 3 is scheduled to begin in 2003. The Multi-element Integration Testing test program has been valuable for demonstrating overall hardware and software compatibility, and identifying any outstanding issues/anomalies prior to launch and assembly on-orbit.

*International Space Station On-Orbit Assembly*

The program expanded the on-orbit capabilities of the Space Station through launch and activation of the U.S. Laboratory, the Canadian-built robot arm, the Italian-built logistics modules, and the U.S. Airlock. The Airlock delivery to the Space Station was accomplished in July 2001, demonstrating the capability to support Station-based space walks (or extra-vehicular activities) without the Shuttle present.

*International Space Station Permanent Human On-Orbit Operations*

In FY 2001, only one Station airlock-based space walk was scheduled. The program completed the walk from the United States Airlock in July 2001, as planned at the beginning of the fiscal year. With the installation of the airlock now complete, the program will begin the transition of using the Space Station Airlock, as well as the Shuttle Airlock, for Station assembly and maintenance space walks. Several extra-vehicular activities using the Space Station Airlock are planned for 2002.

*International Space Station Research Activities*

Delivery of the U.S. Laboratory Destiny in February 2001 set the stage for a significant level of research. Outfitting of the lab began with delivery of the Human Research Facility and two multipurpose payload Express Racks in March and April 2001. Two additional Express Racks were launched in August 2001. Expedition 1 included five payloads in the areas of technology development, human research, and education. Expedition 2 began a more robust program of scientific research, including 18 payloads focusing on biomedical research. The Expedition 3 payload complement includes a total of 5 research racks, plus 10 new payloads, and 8 ongoing payloads, focusing on biomedical and microgravity research. Five additional research racks are planned for delivery to orbit during 2002, along with as many as 60 experiments begun or completed.

*Space Communications*

The Space Communications program supports NASA's enterprises and external customers with space communications and data systems services that are responsive to customer needs. The program performs infrastructure upgrades and replenishment efforts necessary to maintain the service capability that satisfy the approved mission model. The program conducts technology and standards infusion efforts to provide more efficient and effective services.

In line with the National Space Policy, the program is committed to seeking and encouraging commercialization of NASA communications services and to participate with NASA enterprises in collaborative inter-agency, international, and commercial initiatives. NASA procures commercially available goods and services to the fullest extent feasible, and enables the use of existing and emerging commercial telecommunication services to meet NASA's space communications and data systems needs.

20 August 2001. Backdropped by the darkness of space and the blue Earth at its horizon, the International Space Station is seen from the departing Space Shuttle Discovery. The outside of the Quest Airlock of the Space Station now contains the newly installed Materials International Space Station Experiment that will collect information on how different materials weather in the environment of space.

In FY 2001, NASA's ground and space network assets successfully supported all NASA flight missions and other U.S. Government agency, commercial, and international missions. Highlights included:

- Launch of the Mars Odyssey, Microwave Anisotropy Probe, Genesis, Artemis, and Geostationary Operational Environmental Satellite
- Emergency support of spacecraft anomalies to Artemis, Geostationary Operational Environmental Satellite, Solar and Heliospheric Observatory, Mars Global Surveyor, Terra, Tropical Rainfall Measuring Mission, and Cassini
- Deep Space-1 encounter with comet Borrelly
- Astro-D re-entry with impact in the Pacific Ocean
- Landsat-4 end of life burns
- Upper Atmosphere Research Satellite end of life preparation

The program also successfully supported the International Space Station and all Space Shuttle missions. Overall, the networks provided data delivery for all customers at or above the standard of excellence.

The second full year of operational support under the Consolidated Space Operations Contract was successful, with performance levels that met or exceeded all contract metric standards.

Acquisition of commercial Wide Area Network and space-to-ground network support continued to increase. The existing contract with Getronics that provides telecommunication services has been streamlined to improve support while reducing costs. Voice conferencing, video conferencing, and facsimile machine support have recently been outsourced to a Small Disadvantaged Business. An Indefinite Delivery/Indefinite Quantity contract has been established through the Consolidated Space Operations Contractor, Lockheed-Martin, to provide space-to-ground communication services through 14 commercial providers. Under the contract, the initial task order was issued for Southern Hemisphere support in Santiago, Chile. An additional task order is being processed to provide consolidated communications services in Svalbard, Norway, to support polar-orbiting missions.

*Integrated Service Networks*

The program achieved nearly all planned data delivery from space flight missions, as documented, in space, ground, deep space, and NASA-integrated service networks performance metrics with detailed program and project operations requirements in project service level agreements.

## Challenges

Areas of greatest challenge involved:

- Aging Space Shuttle fleet
- Budget and program management challenges for the International Space Station

*Space Shuttle*

NASA has only one human-rated vehicle for carrying people and cargo to and from low-Earth orbit. We must continue to do this in a safe, reliable, cost-effective manner until the next generation vehicle is available. Space Shuttle upgrades and aging infrastructure remain a continuing concern for the program. A safety allocation was provided in FY 2001 to address Shuttle safety improvements through hardware/software upgrades, personnel, facility and infrastructure, or other investments. NASA conducted an external review to assess the Space Shuttle program's prioritization of high-priority safety upgrades investment. The high-priority safety upgrades include the Cockpit Avionics Upgrade Increment 1, Advanced Health Management System Phase I for the Space Shuttle Main Engines, and the External Tank Friction Stir Weld upgrade. During the development of the FY 2003 budget, cost growth was identified in the baseline program. To alleviate a portion of this cost growth, NASA has cancelled or deferred a number of Shuttle upgrades such as the Solid Rocket Booster Advance Thrust Vector Control, and Increment 2 of the Cockpit Avionics Upgrade.

The Electric Auxiliary Power Unit was one upgrade under consideration for the Space Shuttle program during FY 2001. After conducting internal and external reviews for this upgrade, it was determined that the technology lacked maturity and therefore could not ensure manageable cost growth during its development. For FY 2002, the program will continue a minor technology development effort in order to close out this project.

*International Space Station*

The Propulsion Module budget was redirected by the President's Budget Blueprint to core program activities. Therefore, the Propulsion Module schedule milestones were not accomplished during 2001. The Propulsion Module project has subsequently been cancelled. The Crew Return Vehicle budget was also redirected by the President's

Budget Blueprint to core program activities. Therefore, the Crew Return Vehicle Phase 1 schedule milestones were not accomplished during 2001. While our Space Station management and engineering achievements to date have been extraordinary, projected future Space Station cost growth in FY 2003 through FY 2006 continues to constrain the program.

NASA continues to work with the Administration and Congress to resolve the remaining budget challenges. The Space Station program has initiated specific actions to enhance the program's financial management. The Space Station Management and Cost Evaluation Task Force includes a team of outstanding innovators in the fields of science, engineering, finance, and business to advise NASA and the Administration on how to maximize the scientific returns on the Station, while living within the guidelines of the President's budget.

The President's FY 2002 budget requires fiscal discipline, redirects program content (including the Habitation Module, Crew Return Vehicle, and Propulsion Module) and realigns Space Station research to meet constrained funding levels. The President's Budget redefines the "U.S. Core" as the Space Station ready to accept major international hardware elements. NASA is committed to fiscal responsibility and is working to achieve high priority Space Station objectives within the funding limitations established by the Administration and Congress. Consistent with this commitment, the program developed a "Program Management Action Plan, July 2001," which provides a set of management and resource control actions to address institutional and program reforms. In the Program Management Action Plan, the need to improve NASA's management tools and reporting was identified as a result of the NASA bottoms-up review of the Space Station program budget. Until baseline redefinition is completed and the improved management tools and reporting are in place, NASA is shifting program reporting from the Johnson Space Center director, to the NASA Headquarters Office of Space Flight. This action is put in place to broaden the assessment of the current state of the program, provide independent controls over reserve allocation, provide early insight into problems, and focus the complete set of Space Flight resources on the challenges facing the program.

Additional, permanent changes address both specific and general management and resource controls, with four overall objectives: improving cost estimating and control; enabling the integration and prioritization of competing resource requirements; efficiently managing the contractor and civil servant work force; and encouraging innovation and competition. The following table shows specific issues addressed in the plan. The following sections detail actions and responsibilities to address each issue.

NASA remains committed to the lead center concept and fully intends to return Space Station program reporting to Johnson Space Center as soon as practicable after necessary conditions are met. NASA Headquarters and the Administration must be confident that the new baseline will be fully implemented, and the improved management tools and reporting are in place, before the transfer can occur. Three broad objectives must be attained: (1) a new program baseline must be established; (2) sufficient feedback must be gained to demonstrate program baseline stability; and (3) the resource requirements for the new baseline must be evaluated. To support these broad objectives, several actions must be completed, or at least well underway. These include the consolidated management of Johnson Space Center engineering projects and sustaining engineering efforts, the elimination of lower priority tasks to free civil service resources for critical Space Station work, and the implementation of improved cost estimating, resource control, and predictive reporting reforms.

Finally, NASA will explore ways to bring Space Station capabilities in line with earlier research plans. To do this, and remain within the Administration's budget blueprint, NASA may seek innovative means of expanding crew hours for research in the near term, and returning to a six to seven crew capability with an alternative crew habitat solution and a crew return solution for mature operations, within available resources. Sufficient resources must also be applied directly to research projects. The solutions may involve the international partners and/or program participants, commercial concerns, or be developed wholly within the Agency's organic capabilities. In any case, each solution must be part of a fully integrated and justifiable strategy.

The program plan has already implemented several of these reforms, including increasing Headquarters oversight, strengthening business management functions, improving cost estimating and control methodologies, and instituting independent financial assessment capabilities. Several external teams (including the Space Station Management and Cost Evaluation Task Force, House Appropriations Committee Surveys and Investigation Staff, and the NASA Independent Requirements Review) have been chartered to review the program baseline and cost accountability.

**Program Management Action Plan**

| Action Category | Issues Addressed |
|---|---|
| Program Management Organization and Institutional Reforms | • Work load prioritization<br>• Efficient use of personnel resources<br>• Cross-organization integration<br>• Task duplication<br>• Management training |
| Cost Management and Cost Estimating Accuracy | • Cost estimating<br>• Use of independent/external assessments<br>• Training in latest tools/methods<br>• Control of program content<br>• Cost stability and predictive measures of program health |
| Revised Approaches to Space Station Operations | • Integrated "early warning" system<br>• Efficient use of operations infrastructure |

*(Program Management Action Plan table continued)*

| Program Management Action Plan | |
|---|---|
| **Action Category** | **Issues Addressed** |
| Management Innovation and Contracts Competition | • Consistent operations assumptions and ground rules<br>• Competition for operations support contracts<br>• Space Station operations costs |
| Options to Enhance Research Capability | • Enhanced use of planned Shuttle visits as a source of crew time on board the Space Station<br>• Improving maintenance efficiency to increase available crew time for research |

## Assessments

Seven of nine annual achievement goals were achieved (green) in FY 2001. As the table below shows, goals were met in reaching a 100-percent on-orbit mission success, and in the development of new International Space Station integration tests. In addition, we continued to operate the Space Station during assembly, increased research activities aboard the Space Station, increased budget acquisitions of communications and data services from the commercial sector, and achieved at least 95 percent of planned data delivery from space flight missions. Although the goals to complete Space Shuttle safety investment program operations and to complete all Space Station on-orbit activities were not fully achieved (yellow), progress was significant and completion is expected in FY 2002.

**Strategic Goal 2. Enable and establish a permanent and productive human presence in Earth orbit**

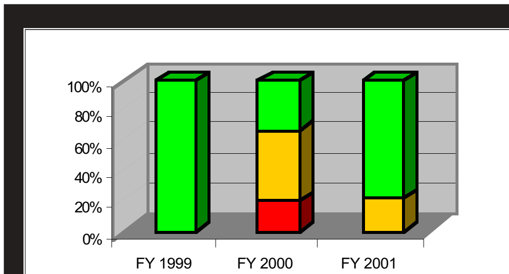
| APG | Description | Assessment |
|---|---|---|
| 1H6 | Have in place a Space Shuttle safety investment program that ensures the availability of a safe and reliable Shuttle system for International Space Station (ISS) assembly and operations. | Yellow |
| 1H7 | The Office of Space Flight continues to invest in Space Shuttle operations. Investments include hardware production, ground processing, launch and landing operations, flight crew operations, training, logistics, and sustaining engineering. | Green |
| 1H30 | Achieve 100% on-orbit mission success. This annual performance goal will be measured against the customer's mission objectives and the post-flight reporting of completion of mission objectives. | Green |
| 1H10 | Development, manufacture and test of the ISS vehicle elements are phased in conjunction with the launch and on-orbit assembly schedule. The annual performance goal is to successfully complete the majority of the planned development schedules and milestones required to support the Multi-element Integration Testing (MEIT). | Green |
| 1H11 | Deployment of the ISS occurs with on-orbit assembly over several years. Successful and timely deployment is dependent on the Shuttle and other international launch vehicles, and the provision of some elements and services from international partners and participants. The annual performance goal is to successfully complete the majority of the ISS planned on-orbit activities such as delivery of mass to orbit and enhanced functionality. | Yellow |

*(Assessment table continued)*

| **Strategic Goal 2. Enable and establish a permanent and productive human presence in Earth orbit** | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 1H12 | Operations of the ISS occur as the vehicle is being developed and assembled. The annual performance goal to successfully complete the majority of combined ISS planned operations schedules and milestones as represented by permanent human on-orbit operations. | ● |
| 1H13 | The conduct of research is an important objective of the ISS. During assembly, the ISS will add pressurized volume, experiment racks, facilities and unpressurized payload accommodations in support of research opportunities. The annual performance goal is to successfully complete the majority of the planned research activities in support of initiation of on-orbit research opportunities. | ● |
| 1H14 | The ISS program has undertaken a series of selected developments and support activities to enhance the robustness of the vehicle, enhance safety and reduce reliance on capabilities contributed by Russia. The annual performance goal is to successfully complete no less than 85% of the planned Russian Program Assurance schedules and milestones required for the development of the Propulsion Module. | N/A |
| 1H15 | Crew transportation and return for up to three crewmembers is planned to be provided by Russia throughout the life of the program. In order to further enhance ISS safety, NASA has initiated the Phase 1 development of a crew return vehicle (CRV) that could provide the U.S. crew return capability to support the emergency return of up to seven crew, the full crew complement planned for the ISS. A U.S. crew return capability is planned for deployment late in the ISS assembly sequence. The annual performance goal is to successfully complete no less than 75% of the planned crew return capability schedules. | N/A |
| 1H20 | Increase the percentage of the space operations budget allocated to acquisition of communications and data services from the commercial sector to 15% in FY 2001. The space communications program will conduct tasks that enable commercialization and will minimize investment in government infrastructure for which commercial alternatives are being developed. | ● |
| 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 with detailed program and project operations requirements in project service level agreements. | ● |

## Trends

Over the last 3 years, the progress and accomplishments of the International Space Station, Space Shuttle, and Space Communications programs have been remarkable. Space Communications consistently meets or exceeds all performance targets in support of its customer's successes. The Space Shuttle continues its outstanding record of safely and successfully supporting all of its customers including Space Station and Hubble Space Telescope. Shuttle upgrade planning performance is improving and associated budget concerns are being addressed. Shuttle mission success and safety metrics continue with a positive trend. Phase II of the International Space Station program has been achieved, providing a fully functional on-orbit facility with research




NASA's ability to enable and establish a permanent and productive human presence in Earth orbit increased substantially from the previous fiscal year.

capability. Assembly and operations experiences have demonstrated NASA's ability to integrate the large and complex Space Station structure on orbit. While Space Station metrics have shown improvement over the 3-year reporting period, NASA continues to work with the Administration, Congress, and other advisory groups to resolve its remaining challenges.

**NASA's telecommunications network spans the world**

The NASA Deep Space Network is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The network also supports selected Earth-orbiting missions.

The Deep Space Network currently consists of three deep-space communications facilities placed approximately 120 degrees apart around the world: at Goldstone, in California's Mojave Desert; near Madrid, Spain; and near Canberra, Australia. This strategic placement permits constant observation of spacecraft as the Earth rotates, and helps to make the Deep Space Network the largest and most sensitive scientific telecommunications system in the world.

**Strategic Goal 3. Expand 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 NASA opens the space frontier, NASA must therefore seek to expand the free market into space.

Challenges

Under the Human Exploration and Development of Space Technology and Commercialization Initiative, achievements not related to annual performance goals could have been accomplished. However, in the spring of 2001, funds were frozen and in the fall 2001, the funds were transferred to the International Space Station Program to cover budget issues. No metrics to report for FY 2001.

**Strategic Goal 4. Share the Experience and Discovery of Human Space Flight**

Americans—of all backgrounds—should have the opportunity to share in the experience and benefits of space exploration and development. During the past 4 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.

Moreover, terrestrial applications of technologies developed for space have saved many lives, made possible medical breakthroughs, and yielded other tangible benefits for

Americans. The further commercial development of space will result in still more jobs, technologies, and capabilities to benefit people the world over in their everyday lives.

Achievements

NASA completed three broadly based student design competitions through the Human Exploration and Development of Space-University Partners, NASA Means Business, and the Great Moonbuggy Race projects. The enterprise also used its Customer Engagement Plan, originally developed in 1999 and updated in 2000 and 2001, to lay the foundation for the Human Exploration and Development of Space Education Implementation Plan, which was released in February 2001. Beyond these formally tracked efforts, the enterprise maintained its public web sites and added a new web site for its Advanced Programs office. In June 2001, a set of six compact discs was released to help communicate the reality and potential of NASA's space flight and science exploration programs. Continuation of outreach events like the Johnson Space Center Open House and viewing opportunities for Shuttle launches further contributed to this year's successful achievement of this goal.

In addition, the work that went into conceptualizing and developing the Customer Engagement Plan also served as the foundation for creating the July 31, 2001 cross-cutting NASA Procedures and Guidelines 1090 document, detailing "The Communicate, Engage, Inspire Process" (a rewrite of the Communicate Knowledge factor defined in the NASA Strategic Plan).

Challenges

In our quest to successfully communicate the benefits of human space flight to the public, the Office of Space Flight is repeatedly challenged by the need to:

- Develop and implement innovative activities and programs that continue to engage/educate the public regarding the benefits of human space flight, all within the legal requirements and limitations.
- Develop appropriate partnerships or collaborations in an effort to extend NASA's reach in promoting effective education and outreach efforts.
- Secure the requisite resources (e.g., funding, appropriate expertise, time) to provide effective and dynamic education and outreach programs, while competing for limited financial resources in a technology-based organization.

Assessments

This newly-established annual performance goal, the completion of a broadly-based student design competition on innovative design concepts that address technological challenges, along with a customer engagement plan, was achieved (green) in FY 2001.

| Strategic Goal 4. Share the experience and discovery of human space flight | | |
|---|---|---|
| APG | Description | Assessment |
| 1H26 | Human Exploration and Development of Space (HEDS) will complete a broadly based student design competition on innovative design concepts that address HEDS technological challenges and complete a customer engagement plan. | Green |

Trends

A single annual performance goal was established to support this strategic goal. No trend data are available.

## Awards, Honors, and Distinctions

As a leader in human space exploration and development, NASA has received its share of scientific and technical recognition. However, when the jury convened on June 13, 2001 and announced the Space Station had won the Prince of Asturias Award for International Cooperation, there was special pride. The jury proclaimed the Space Station to be mankind's most important step toward conquering space and a milestone for scientific research beyond the Earth. It is also a symbol of the potential for mankind's future of technological development, scientific breakthrough, and peaceful cooperation among nations for the benefit of the whole planet. The nomination points out that "this adventure has already contributed, and will continue to do so, in an exemplary and practical fashion, to progress and fraternity amongst nations fulfilling the principles laid down in the 1967 Treaty for Space to explore and exploit outer space for the benefit of all mankind and for international cooperation in all scientific work that is carried out." A hallmark of the future, says the nomination, "is the need for our civilization to embark on many major projects by applying extensive international cooperation to confront the uncertainties of the future," and it considers the Space Station to be "the first of these colossal projects."

Another example of recognition for efforts supported by the enterprise this past year was the receipt of the American Institute of Aeronautics and Astronautics Space Systems Award for 2001. The institute annually recognizes outstanding achievements in the architecture, analysis, design, and implementation of space systems. NASA, Boeing-industry, and the International Partner Space Station Team were the recipients of the award at the American Institute of Aeronautics and Astronautics Space Technology Conference and Exposition in August. The award certificate reads: "For its extraordinary efforts to design, develop, assemble and operate the International Space Station."

## Partnerships

NASA continues to work with the 16 countries participating in the International Space Station. These include Russia, Japan, Canada, and participating countries of the European Space Agency, including Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and Brazil.

**The International Space Station is an enduring symbol of international cooperation**

24 April 2001. Yury V. Usachev, Expedition 2 mission commander; Yuri V. Lonchakov, STS-100 mission specialist; Scott E. Parazynski, STS-100 mission specialist; Umberto Guidoni, STS-100 mission specialist; and Chris A. Hadfield, STS-100 mission specialist, pose in the Zvezda Service Module wearing baseball caps representing their home countries, showing the true flavor of the International Space Station. Usachev and Lonchakov represent Rosaviakosmos, the Russian space agency, Guidoni represents the European Space Agency, Parazynski represents NASA, and Hadfield represents the Canadian Space Agency.

# Aerospace Technology

*NASA's aerospace technology mission is to pioneer the identification, development, verification, transfer, application, and commercialization of high-payoff aerospace technologies. Our research and development programs contribute to national security, economic growth, and the competitiveness of American aerospace companies. Aerospace technology plays a key role in maintaining a safe and efficient national aviation system and enabling an affordable, reliable space transportation system. NASA 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.*

# Aerospace Technology

## Strategic Goals

To achieve our mission, NASA is pursuing four strategic goals:

1. Develop an environmentally friendly global air transportation system of unquestioned safety that improves the Nation's mobility.
2. Revolutionize air travel and the way in which air and space vehicles are designed, built, and operated.
3. Achieve the full potential of space for all human endeavor through affordable space transportation.
4. Enable, and as appropriate provide, on a national basis, world-class aerospace research and development services, including facilities and expertise.

NASA research and technology is investing in high-risk, high-payoff activities for this country. We purposefully establish challenging annual performance goals to strive for revolutionary advances, while recognizing that research by its nature is dynamic. Breakthroughs and discoveries cannot be attached to a firm schedule. Seeking the best performance for each taxpayer dollar is a management challenge that must accommodate responding to unexpected events, uncovering unknowns, and employing knowledge gained to adjust research plans. Our research does not end with discovery, but includes maturation and testing, which are essential for successfully transferring our technologies to industry.

### Strategic Goal 1. Develop an Environmentally Friendly Global Air Transportation System for the Next Century of Unquestioned Safety That Improves the Nation's Mobility

Technology is an engine that drives development, and our aerospace industry is a prime technology provider. Air transportation is essential to the economic success of America; without it we could not be competitive in the global marketplace. Air transportation makes it possible to move millions of people and goods worth billions of dollars to markets around the world. There are no other practical alternatives. The growth in air traffic is pushing the aviation system to its limits. Physical and environmental constraints threaten to halt the growth required to support our economy. Although the events of September 11, 2001, have added additional challenges to aviation, the basic constraints still remain.

A foundation of U.S. leadership in aviation and space technology has been our steadfast investment in research. The first strategic goal is to enable the safe, environmentally friendly expansion of aviation. Demand for air transportation is growing in the U.S. and worldwide. At the same time, the public is demanding cleaner, quieter, and faster aircraft. Meeting these somewhat competing demands calls for forward thinking, new concepts, and global coordination.

#### Achievements

We divided this goal into four performance objectives: 1) Improving the safety of the traveling public. 2) Improving the environment by reducing aircraft emissions. 3) Reducing noise in the communities surrounding airports. 4) Developing methods to use the airspace more efficiently thereby increasing its capacity. The following sections describe significant achievements in these areas.

*Safety Improvements*

In 1997, NASA developed a series of updated “stretch” objectives for its Strategic Plan. The stretch objective for safety is to provide enabling technology to reduce the aircraft accident rate by a factor of 5 within 10 years and by a factor of 10 within 25 years. Federal Aviation Administration accident statistics for 1993 through 1996 serve as the reference baseline. In partnership with the Federal Aviation Administration and the aviation community, our activities aim to dramatically reduce aircraft accidents and to reduce aviation-related injuries and fatalities.

We examined historical accident trends to identify strategic investment areas where a suite of high-payoff technologies could improve flight safety. We established key research projects for the areas hazardous weather, controlled flight into terrain, human-performance related causal factors, and mechanical or software malfunctions. In addition, the enterprise will begin developing and integrating the information technologies needed to assess situations and trends that indicate unsafe conditions, and provide warnings before they lead to accidents. These investment areas address all parts of the aviation system, including aircraft, people, and operations.

The goal was to complete 75 percent of the conceptual designs of systems for preventing and mitigating accidents, and to demonstrate tools for analyzing accidents and assessing risks. We met our system design target, but were unable to demonstrate the tools in FY 2001, though they will be delivered in 2002. During FY 2001, system design concepts in the areas of fire prevention, fire detection, synthetic vision, and integrated vehicle health management were selected for continued development.

**NASA works to reduce aviation fatalities**

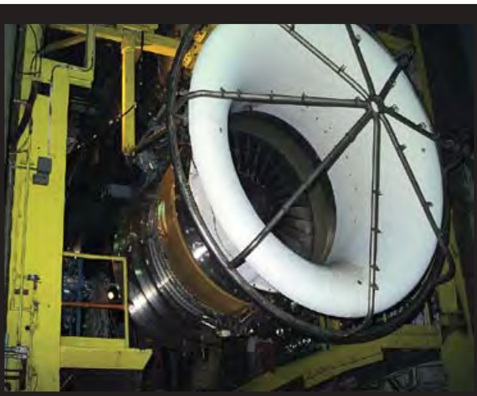
Limited visibility is the single greatest contributing factor in most fatal airline and general aviation crashes worldwide. NASA is working with industry to create a Synthetic Vision System, a set of technologies that together can provide pilots with a clear view of their surroundings, including other aircraft present, regardless of the time of day or weather conditions outside the cockpit. Such “situational awareness” will enhance pilot decision-making for increased safety. This cockpit view is created from a digital terrain database of an approach into Vail, Colorado.

The synthetic vision system technology has the potential to eliminate low-visibility conditions as a cause of civil aircraft accidents. The system provides the pilot a clear, sunny day view, regardless of the outside weather conditions or time of day. Flight evaluations comparing conventional displays to synthetic vision displays were conducted over a 3-week period during August-September 2001. The pilots, representing industry, the Federal Aviation Administration, and 3 major airlines, conducted 11 research flights for a total of 106 airport approaches, performing tests designed to assess system acceptability and usability. Early results indicate that pilots experienced improved awareness of the relation of the aircraft to the ground when using the synthetic vision displays.

Another revolutionary technology that shows promise in eliminating causes of aircraft accidents is a flight control system that can compensate for damaged control surfaces (for example, flaps) or an engine failure during flight. This capability, which was successfully simulated on the ground this past year, uses a "neural net" flight control architecture to activate unaffected control surfaces and engines to compensate for the failed ones. The "neural net" is a biologically-inspired computer brain that assesses damage and develops unique strategies to allow an aircraft to continue flying safely.

*Emissions Reduction*

The objective is to reduce harmful emissions of future aircraft by a factor of 3 in 10 years and a factor of 5 within 25 years. Our reference baseline is the 1996 emissions standard established by the International Civil Aviation Organization, the international body chartered to formulate aviation standards.



**NASA reduces emissions in production engines**

Smog and other air quality concerns due to aircraft emissions are being helped by NASA research on critical engine technologies. Engines that reduce nitrogen oxide and carbon dioxide (NASA's goals are for 70-percent and 15-percent reductions respectively) are a tremendous benefit to airlines, which would save on environmental taxes at airports, as well as fuel costs. The importance of emissions reduction is shown by how quickly the technology has been adopted. A new combustor technology that demonstrated a 50-percent nitrogen oxide reduction on a test stand in 2001 (shown here on a Pratt & Whitney 4000 engine) is already in production.

Among the chemicals produced during the combustion of aircraft fuel, two have the most significant impact on the environment. Nitrogen oxide degrades local air quality through the creation of smog and carbon dioxide impacts global air quality by contributing to the loss of the ozone. NASA is addressing this problem by developing critical engine technologies that provide a significant reduction in nitrogen oxide emissions, and by developing aircraft and engine technologies that provide a dramatic increase in efficiency (e.g., lighter weight structures, resulting in reduced fuel use). By reducing the amount of fuel burned, both nitrogen oxide and carbon dioxide emissions will likewise be reduced. The fuel efficiency improvements have been forecast to be as high as 25 percent. An expected side benefit of this efficiency would be a reduction in the cost of air travel.

The maturation of emissions technology is key to its successful transition to industry. This is normally accomplished through a deliberate buildup of complexity in the testing of components, from the laboratory, then to more realistic environments, and finally to full integrated systems testing in an operational environment.

Our performance target was to assess the benefits of a flow control concept for low-pressure turbine designs and demonstrate a turbine disk alloy, with an upper temperature of 10 percent greater than current alloy. We accomplished each of these tasks as planned.

During FY 2001, industry and NASA design teams developed conceptual designs of advanced engines for each of the different classes of aircraft. These advanced designs, using anticipated ultra-efficient engine technology now under development, could be available for production as early as 2010. System analyses indicate that all designs meet or exceed the ultra-efficient engine technology goals of 70 percent nitrogen oxide reduction (from the 1996 baseline) and 15 percent carbon dioxide reduction for the subsonic transports, and 8 percent carbon dioxide reduction for the supersonic business jet. Achieving both nitrogen oxide and carbon dioxide goals in the same engine is especially challenging as the design for one requirement is typically in opposition to the design required for the other. The importance of NASA's research is clear. During 2000, in partnership with the aircraft engine industry, NASA demonstrated a 50 percent nitrogen oxide reduction. Without that demonstration, this technology would not yet be incorporated into production engines as it is today.

*Noise Reduction*

The objective is to reduce perceived noise levels of future aircraft by a factor of 2 in 10 years, and by a factor of 4 in 25 years. We are using noise generated by a representative 1997 production aircraft as the reference baseline.

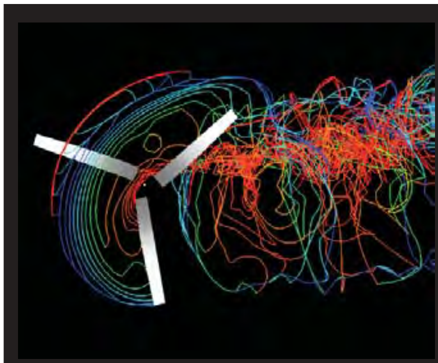
NASA's vision for our air transportation system is to develop technology that enables objectionable aircraft noise to be contained within airport boundaries to meet the quality of life expectations of our citizens. NASA is investigating engine and airframe technologies and aircraft operation concepts to address these goals. Systems studies show both engine and airframe noise sources must be attacked to produce any significant reduction in the total aircraft noise.

Our goal was to complete a large-scale demonstration of a 2- to 5-decibel reduction in aircraft noise from the 1997 baseline, and to assess concepts offering additional reductions. (A decibel is a standard measure of noise. Small decibel reductions translate into major reductions in noise; for example, a 3-decibel reduction is comparable to half the sound.) The testing of the technologies and the integrated system analysis of the results were completed in December 2001.

Full-scale static engine testing was conducted on a Pratt & Whitney 4098 engine to validate a combination of several technologies, including an acoustic liner and improvements to the engine inlet. Airframe noise reduction concepts were validated on a detailed reduced-scale Boeing 777 model. Two tests were conducted to validate engine system noise reduction in a flight environment. A serrated nozzle and other jet noise reduction concepts were validated on a Lear 25 aircraft, and both jet and fan noise reduction concepts were validated on a Falcon 20 aircraft. In order to validate the cumulative noise reduction effect of these technologies, a computer analysis was required to integrate the results of the individual component tests. A systems analysis completed in December 2001, validated that these technologies exceeded the minimum goal of a 2-decibel reduction in perceived aircraft noise.

*Capacity Increase*

The objective in aviation system capacity is to safely triple the number of aircraft that can use the Nation's airspace in all weather conditions within 10 years. We are using 1997 operational data from the Nation's 64 busiest airports as the reference baseline.



**NASA uses computer visualization to decrease tiltrotor noise**

NASA is developing the tools and technologies to attack the noise producing elements inherent in aircraft designs. One such tool is computer visualization used to understand the way noise is generated in order to develop and apply the most effective abatement technologies. Here a computer visualization of isolated V-22 tiltrotor wakes shows complex aerodynamic interactions taking place in rotorcraft flight. Creating a "quiet" tiltrotor could open a new market for commuter aircraft by allowing greater flexibility in flight destinations and more efficient use of airport runways.

The flight delays in the U.S. aviation system have increased significantly over the past 6 years, with the peak delays during the summer months having doubled in only 4 years, from 1996 to 2000. Passenger demand and adverse weather drive these delays. With the disruption of air travel by the events of September 11, 2001, the problem is expected to continue escalating due to the demand for passenger and cargo flights. Along with impacts on the flying public, flight delays also impact the economy as more than one-quarter of the Nation's exports, based on value, are shipped by air. NASA is developing the technologies that will increase the capacity of the National Airspace System, alleviating these delays without compromising safety.

A civil tiltrotor aircraft was investigated for runway-independent commuter-aircraft operations that would free up the runways to allow additional large aircraft to land, effectively increasing the capacity of an airport. A tiltrotor can land like a helicopter in a very small area, yet fly like an aircraft in its cruise mode. Its military cousin is the V-22 Osprey. The barriers to its acceptance are the levels of noise generated and assuring officials and the public that noise abatement measures can be implemented while maintaining safe flying qualities. NASA successfully concluded its civil tiltrotor program, and transferred to industry several related technologies, including low-noise proprotor designs, the capability to design and evaluate efficient low-noise tiltrotors, and safe, low-noise landing and take-off profiles. NASA's civil tiltrotor project produced a comprehensive simulation database of operating procedures needed for flying the complex, low-noise flight paths. The database validated that low-noise profiles could be safely accomplished, even in adverse conditions.

NASA also continued its close work with the Federal Aviation Administration and provided it with three additional tools to increase the efficiency of the National

Airspace System. The Collaborative Arrival Planner tool has proven so beneficial that it is already in use with the Federal Aviation Administration and airlines. This tool exchanges real-time air traffic control information with airline operational control centers, such that aircraft operation decisions made by the control centers are based on the most up-to-date information.

## Challenges

NASA is investing in high-risk, but high-payoff research and technology activities. Seeking the best performance for each taxpayer dollar is a management challenge that must accommodate responding to unexpected events, uncovering unknowns, and making adjustments as knowledge is gained. Developing these technologies is only the first step. In order to obtain the benefits of the research, NASA must also work closely with all potential users (e.g., U.S. Department of Defense, Federal Aviation Administration, private industry) to identify opportunities for the expeditious and efficient transfer of NASA-developed technologies into commercial and military applications. In this process, care must be taken to balance the desires of the user community for near term technology development with the need to develop the revolutionary and breakthrough technologies required for the aviation systems of the 21st century.

## Assessments

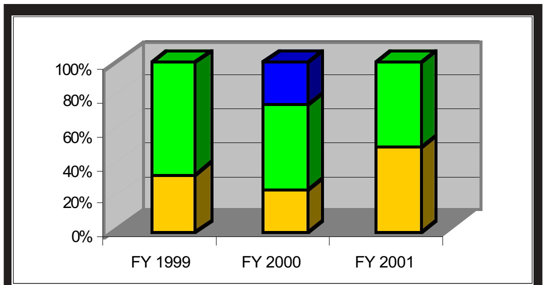
Two of four annual performance goals were achieved. The goals aimed at emissions reduction and airspace systems capacity increases were met (green). Although the goal for aviation safety was not met (yellow) due to delays in developing the tools for risk assessment, approximately 85 percent of all indicators were met as scheduled. The risk assessment tools will be completed in 2002. The noise reduction goal was not met on time (yellow). The development and testing of all planned noise technology was completed in FY 2001. The technology has been transferred to industry and is being incorporated into their products.

**Strategic Goal 1. Develop an environmentally friendly global air transportation system for the next century of unquestioned safety that improves the Nation's mobility**

| APG | Description | Assessment |
|---|---|---|
| 1R1 | Complete 75% of the conceptual designs of systems for preventing and mitigating accidents, and demonstrate tools for accident analysis and risk assessment; indicators include information data base and tool development, system architecture definition and evaluation, as well as ground and flight tests. | Yellow |
| 1R2 | Complete one system level technology benefit assessment, one component concept selection and one new material system; indicators include a technology benefit assessment, advanced concepts definition and selection, development of advanced materials and design methods. | Green |
| 1R3 | Complete 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; indicators are results of large scale component ground tests and analytical noise predictions, respectively. | Yellow |
| 1R4 | 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; indicators include demonstrations of decision support and communication tools, as well as design databases. | Green |

Trends

Overall, FY 2001 annual performance goal achievement in developing a safe, environmentally-friendly global air transportation system was 50 percent (green). This represents a decrease from FY 2000's achievement rate of 75 percent (blue and green combined), and FY 1999's achievement rate of 67 percent.



Performance in achieving the strategic goal of developing a safe, environmentally friendly global air transportation system decreased in FY 2001

**Strategic Goal 2. Revolutionize Air Travel and the Way in Which Air and Space Vehicles are Designed, Built, and Operated**

NASA's second strategic goal is to revolutionize air travel and the way in which aircraft are designed, built, and operated. Creating radically new tools and work environments in which engineers and designers develop their ideas and products will be key in achieving our performance goals. Revolutionary technologies and tools will allow the U.S. aerospace industry and our military to maintain a competitive edge. Pursuing technology fields that are in their infancy today, and accelerating the introduction of new technologies while understanding their risks, costs, and benefits, are just some of the challenges we face. The requirement for safety in highly complex aerospace systems is among the most stringent of our challenges.

Achievements

The following sections describe FY 2001 achievements in revolutionizing air travel and the way in which air and space vehicles are designed, built, and operated. We divided this goal into three performance objectives: 1) Revitalize general aviation. 2) Improve design tools. 3) Develop next generation experimental aircraft.

*General Aviation Revitalization*

The objective is to invigorate the general aviation industry so it can deliver 10,000 aircraft annually within 10 years and 20,000 aircraft annually within 25 years.

For FY 2001, our performance goal was to complete the Advanced General Aviation Transport Experiment program by validating transportation system concepts through flight tests and publishing design guidelines, and to complete at least one partnership agreement in general aviation.

The Advanced General Aviation Transport Experiment was a very successful, cooperative venture with the general aviation industry. When this program began, the industry was at an all-time low in the production of aircraft (less than 1,000 U.S. aircraft were produced per year). The consortium was a contributing factor to the industry's recovery. The lessons learned in the experiment have contributed to the successful initiation of the Small Aircraft Transportation System program. The technologies being developed will permit small aircraft operations at virtually any of the thousands of airports in the United States, including those without control towers. This dramatic increase in reliable access to small airports creates transportation services that allow more people to travel to more places, in less time, and at an affordable price. While not specifically designed for current commercial operations, the targeted technologies could provide benefits to commuter and major air carrier operations in the hub-and-spoke system as well.

In FY 2001, the Advanced General Aviation Transport Experiment successfully flight tested a "highway-in-the-sky" operating capability, a datalink infrastructure facility system, and simplified flight controls. With the live demonstration of all these capabilities at the Air Venture Air Show in Oshkosh, Wisconsin, the experiment's technology program was complete. The publishing of the associated design guidelines, system standards, certification bases, and methods was completed in December 2001.

**HITS Phase II displays are aimed at making flying accessible to anyone**

NASA, with a consortium of partners, is developing technology that will significantly increase the safety, utility, and ease-of-flying for general aviation class aircraft. Affordable "Highway in the Sky" glass cockpit technology (shown) will provide pilots with direct access to all the information needed to safely determine their routes, speeds, and proximity to bad weather conditions, terrain and other aircraft. This will open up the skies and the over 6,000 underutilized small airports to more commerce, and personal and business travel.

The Small Aircraft Transportation System is the first step in developing and validating vehicle, communications, and information technologies that will allow small aircraft to operate easily and affordably at small airports in most weather conditions. The follow-on system research and technology program began with work on systems engineering plans, including the flight demonstrations required to validate the system's operating concept. In July 2001, the goal of establishing one partnership agreement was exceeded when four teams were selected to participate in the program: the Maryland Laboratory, the North Carolina-Upper Great Plains Laboratory, the Southeast Laboratory Consortium, and the Virginia Laboratory. Each team includes representatives from state aviation/transportation departments, private industry, general aviation user groups, academia, and other non-profit organizations.

*Next Generation Design Tools*

The objective is to provide next generation design tools to increase design confidence, and cut the development cycle time for aircraft in half.

NASA is now looking at new tools and technologies that will fundamentally change our engineering culture. In our commitment to cutting cost and cycle time while improving safety and the quality of new products, these tools will change the process of traditional engineering. Tools that simulate requirements, design and analyses, prototyping, manufacturing, training, operations, and maintenance, thus accounting for the complete life cycle, will allow engineers to create the "right" design the first time. This approach will save time (design, manufacturing, maintenance) and costs over the entire life cycle of the vehicle.

The goal was to develop at least three new design tools, conduct at least four demonstrations of advances in computation and communications, and complete the intelligent synthesis proof-of-concept capability tested in a laboratory environment.

The most significant tool development was the ability to predict abrupt wing stall, or loss of lift, in fighter aircraft. This sudden stall can occur with small changes in angle of attack, or sideslip, and results in the significant loss of lift for one wing, causing severe rolling motions. This unintended motion has occurred in a variety of tactical aircraft, including the F-18E, YF-16, YF-17, F-15, and EA-6B. Historically, flight tests were the only reliable way to find solutions to the problem. For example, since it was the only alternative, the F/A-18E was forced into 1.5 years of developmental flight-testing and evaluation of over 100 different configurations and over 500 flights, costing millions of dollars before a solution was found based on a NASA-developed porous membrane technology.

NASA is developing wind tunnel testing methods that focus on finding design characteristics that cause abrupt wing stall during the early stages of aircraft design and eliminating them before the aircraft is built. Our aim is to insure that any potential problem is eliminated before flight testing is started. In FY 2001, working jointly with the U.S. Navy and the U.S. Air Force, NASA developed validated figures of merit for identifying abrupt wing stall, and is continuing to complete design guidelines and procedures for preventing it and other uncontrolled flight motions for high performance aircraft.

As the complexity of aerospace vehicles grows, so will the complexity of the design environments. Design teams of the future will be formed by members located at various sites, yet the teams will be expected to perform in a highly collaborative manner. Proofs of concepts for an intelligent synthesis environment were developed in FY 2001. Part of this environment is a secured high performance network to support distributed collaboration. Two specific applications include an International Space Station simulation that models the vehicle and system performance in any user-selected configuration and environment, and a virtual Shuttle ground operation simulation. Both of these simulation environments have a positive impact on customer operations, with reductions in time and improvements in quality.

*Next Generation Experimental Aircraft Development*

NASA is about opening the air and space frontier. Our heritage of experimental aircraft programs continues to push the envelope. Experimental aircraft, or X-planes, are invaluable tools for exploring new concepts, and for complementing and strengthening laboratory research. In the very demanding environment of flight, X-planes are used to test innovative, high-risk concepts, accelerating their development into design and technology applications.

The annual performance goal for 2001 was to demonstrate two new concepts in flight and identify five new concepts for further examination.

The unique Helios solar-powered flying wing, developed by AeroVironment, Inc., for NASA, reached an altitude of 96,863 feet during an August 13 flight from the Hawaiian island of Kauai. Although barely short of the project's 100,000-foot altitude goal, it is the highest ever flown by a nonrocket-powered aircraft in sustained horizontal flight. It was well above the world record of 85,068 feet, set by a U.S. Air Force Lockheed SR-71A reconnaissance aircraft in July 1976. It also surpassed the existing altitude record of 80,201 feet for propeller-driven aircraft, set by the Pathfinder-Plus (Helios predecessor) in August 1998. The 96,863-foot record is pending certification by the Fédération Aéronautique Internationale.

**The Helios Prototype sets a new record**

The Helios is one of the unique remotely operated, solar powered, unmanned aerial vehicles being developed for very high-altitude applications. This experimental vehicle has two major milestones: reaching an altitude of 100,000 feet, and sustaining flight above 50,000 feet, nonstop for 4 days. It has reached 96,863 feet, well above the current record of 85,086 feet for nonrocket- powered aircraft. These vehicles have great potential as scientific platforms for atmospheric sampling and Earth imaging, as well as communication relays, reducing dependence on satellites and serving areas not currently covered by satellites.

Production variants of Helios might see service as long-term environmental or disaster monitors for the Earth, as well as communications relays. These aircraft would reduce dependence on satellites and provide service in areas not covered by satellites. The record-altitude flight also provided information on how an aircraft would fly in a Mars-like atmosphere, since Earth's atmosphere at 100,000 feet is similar to the atmosphere near the Martian surface.

Challenges

The X-43A was designed to be the first scramjet-powered vehicle capable of attaining speeds as high as Mach 10. The vehicle's first flight, June 2, 2001, was to be the first in a series of three. It was lost moments after the launch vehicle was released from the wing of the NASA B-52 carrier aircraft. Following ignition, the launch vehicle experienced a structural failure and deviated from its flight path, which resulted in its commanded destruction. A Mishap Investigation Board was immediately formed and is conducting a thorough review of the failure. The board findings will be addressed prior to scheduling the next X-43 flight.

Assessments

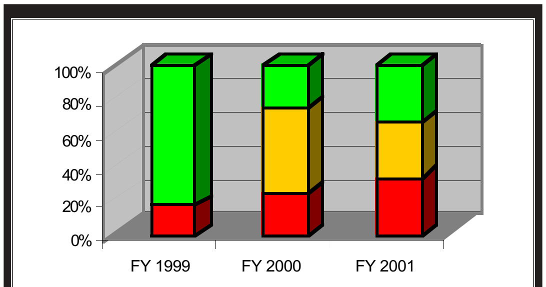
One of three FY 2001 annual performance goals was achieved (green). The goal to complete the Advanced General Aviation Transport Experiment project was not met during FY 2001 (yellow). All of the technology development and testing was completed, but the publication of results did not occur until December 2001. The enterprise failed to achieve the performance target to demonstrate and identify new flight concepts (red) due to a launch system failure that caused the destruction of the first of three planned X-43 test vehicles. A recovery plan is in development, but it is unlikely that a flight will take place in FY 2002.

**Strategic Goal 2. Revolutionize air travel and the way in which air and space vehicles are designed, built, and operated**

| APG | Description | Assessment |
|---|---|---|
| 1R7 | Complete the Advanced General Aviation Transport Experiments project by validating transportation system concepts through flight test and publish design guidelines; indicators include simulations and flight tests, and published design guidelines and standards. Also establish at least one partnership agreement on Small Aircraft Transportation System program. | Yellow |
| 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 systems capability build to technology readiness level 3: indicators include computer testbed demonstrations, real-time remote access of data, new design methods and an intelligent synthesis environment proof-of-concept system. | Green |
| 1R9 | Demonstrate two new concepts in flight and identify five new concepts for further examination; indicators include vehicle development, flight tests and systems analyses of advanced concepts. | Red |

## Trends

In FY 2001, we achieved 33 percent (green) of our goals in revolutionizing the air and space transportation system. This represents an increase over FY 2000, when 25 percent were achieved, and a decrease from FY 1999, when 83 percent of the goals were achieved. It should be noted that the 2000 and 2001 goals were primarily flight events, and 1999 was primarily preparatory activities towards flight.



Performance in achieving the strategic goal of revolutionizing the air and space transportation system increased in FY 2001 after a decline in FY 2000.

## Strategic Goal 3. Achieve the Full Potential of Space for All Human Endeavor Through Affordable Space Transportation

To achieve the full potential of space for all human endeavors through affordable space transportation, NASA envisions successive but overlapping efforts to dramatically reduce costs and increase the reliability of launch systems. The objective is to reduce the cost of putting a payload into low-Earth orbit by an order of magnitude, from $10,000 to $1,000 per pound, within 10 years, and by an additional order of magnitude within 25 years. These future transportation systems expand human exploration and development of space by enabling a broad expansion in scientific research, opening new commercial markets, and ensuring an unprecedented presence for national and international security.

## Achievements

Safe and affordable Earth-to-orbit space transportation is key to the commercial development and civil exploration of space. NASA is developing the technologies and architectures for the next generation of reusable launch vehicles to substantially reduce the resources that would be needed for routine space operations, while increasing the safety and reliability of these systems.

The X-34 program was restructured to address a lack of redundancy in vehicle control systems, a potential safety hazard. To provide this redundancy, significant additional work would be required. The X-34 program applied for additional funding of its risk-reduction activities in competition with other technology development proposals under the Space Launch Initiative solicitation. The X-34 was not selected for continuation during this competition and was therefore terminated.

The X-33 program was planned to build a subscale flight demonstrator of a single-stage to orbit reusable launch vehicle. Significant progress was made in several areas, including a revolutionary linear-spike engine, thermal protection systems, and intelligent vehicle health management. However, the development of a composite tank to contain the liquid hydrogen fuel proved extremely challenging, a difficulty that would require significant additional funds to overcome. As a result of the knowledge gained, the single-stage to orbit concept was reassessed in light of the improvements in two-stage to orbit concepts during competition for technology development proposals under NASA's Space Launch Initiative solicitation. The X-33 was deemed a lower priority and discontinued.

The X-33 and X-34 programs provided valuable technology insight that directly benefited the Space Launch Initiative. The Space Launch Initiative programmatic approach leverages these lessons learned and the technologies. It also focuses on systems engineering to ensure investments support the goals; convergence with defense requirements and commercial needs to capture a greater launch market; commercial practices to reduce cost; and competition to drive innovation and provide technical and business options for informed decisions by senior leadership.

The Space Launch Initiative is NASA's program to develop architectures and technologies for the next generation of launch vehicles beyond the Space Shuttle. These investments will enable a mid-decade competition of space transportation system designs, directly leading to the full-scale development of a second-generation reusable launch vehicle. The technologies being developed—such as crew escape systems, long-life rocket engines, and robust thermal protection systems—will dramatically increase safety and reduce costs. Based on the evaluation of proposals, NASA awarded contracts in FY 2001 valued at $767 million to 22 contractors, including large and small companies. The contracts will be used to develop new strategies, as well as technologies in 10 key areas identified to reduce the risk associated with future launch vehicles.

## Challenges

The safety and affordability goals that we established for the next generation of reusable launch vehicles are very challenging stretch goals. Achieving these goals will require the development of several advanced technologies by the middle of the decade. The coordination, management, and assessment of the technology development effort and integration into viable architectures will be a challenging endeavor.

Assessments

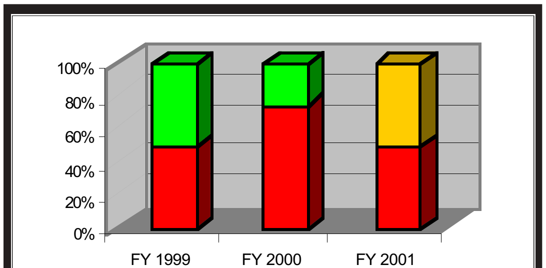
The FY 2001 performance goal was to assemble the third X-34 test vehicle, demonstrate 75 percent of the supporting technology development, and complete competitive solicitations for expanded second-generation reusable launch vehicles in the Space Launch Initiative. The X-34 test vehicle assembly was not met (red). Due to a cost-to-benefit decision, the X-34 program was terminated. The Space Launch Initiative made significant progress in FY 2001, its first year. Space Launch Initiative has completed a major NASA Research Announcement valued at $800 million while preparing and completing a multitude of systems requirements documents and reviews. The launch of the Propulsive Small Expendable Deployer System, a Pathfinder flight experiment, was delayed due to an U.S. Air Force decision to launch a higher priority payload (yellow). The system was scheduled as a secondary payload on the U.S. Air Force mission and is now scheduled for launch in FY 2002. The X-37 vehicle assembly was started as planned.

**Strategic Goal 3. Achieve the full potential of space for all human endeavor through affordable space transportation**

| APG | Description | Assessment |
|---|---|---|
| 1R10 | Complete assembly of the third X-34 test vehicle, demonstrate 75% of supporting technology developments (programmatic performance indicators in appendix), and complete competitive solicitations for expanded 2nd generation reusable launch vehicle efforts; indicators for supporting technology development include both flight tests and ground tests. | (red) |
| 1R11 | Commence X-37 vehicle assembly, and complete one Pathfinder flight experiment. | (yellow) |

Trends

Overall in FY 2001, NASA did not complete its planned goals for achieving the full potential of space (yellow and red). This was a decrease from FY 2000's 25-percent achievement rate (green) and FY 1999's 50-percent achievement rate.



Performance in achieving the strategic goal to reach the full potential of space decreased in FY 2001, although substantial progress was made.

**Strategic Goal 4. Enable, and as Appropriate Provide, on a National Basis, World-Class Aerospace Research and Development (R&D) Services, Including Facilities and Expertise**

To implement world-class research and development services, NASA conducts a broad array of outreach activities. Customer satisfaction surveys conducted at NASA Research Centers help gauge and improve these services, including wind tunnels, motion-based simulators, and a range of educational efforts. Also essential to this strategic goal is transferring NASA's technology to its customers.

NASA continued to solicit customer feedback on its services, facilities, and expertise, and continued the implementation and establishment of current and new education outreach plans.

In FY 2001, NASA developed education plans for its new technology programs, including the Small Aircraft Transportation Systems program, the Quiet Aircraft Technology program, the Second-Generation Reusable Launch Vehicle program, and the Intelligent Systems program. As part of our educational outreach, we produced a jet engine demonstration model for the Explorer Scouts and "The Plane Game" for grades 2-6. Additionally, we helped to produce several award-winning program series that are broadcast on NASA's distance-learning television network, including NASA Connect, The "Why" Files, and Destination Tomorrow. We sponsor "Earth to Orbit," an engineering design challenge program for grades 6-9, "NASA Explore," a weekly aerospace technology curriculum supplement for grades K-12, "The Wright Way," a web site celebrating the centennial of powered flight, and a host of educational programs for all ages.

### Achievements

Three NASA Research Centers (Ames, Glenn, and Langley) conducted customer satisfaction interviews at selected wind tunnels and motion-based simulators to both gauge and improve their services to users. For the nearly 80 surveys received during FY 2001, over 80 percent of the respondents were "highly satisfied" (8 points or higher rating on a 10-point scale) with the service and 100 percent responded as "satisfied" (5 or higher rating). Also in FY 2001, the user community acknowledged the transfer of fifteen new technologies and processes, ranging from modification to aerospace design codes to new low noise approach paths for rotorcraft.

### Challenges

The expeditious and efficient deployment of NASA-developed technologies to customers is a challenging exercise, particularly while maintaining the proper balance necessary between near- and long-term revolutionary technology development. To assist in the process, NASA will have the National Research Council conduct a quality review of research programs. In addition to the transfer of technology, a second challenge is to ensure that NASA knowledge and expertise are used to further the national educational goals. In particular, our programs are based on national curriculum standards, state and local curriculum frameworks, and the research agenda of NASA and the higher education community.

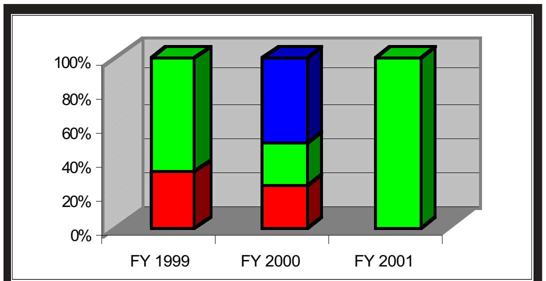
### Assessments

Both FY 2001 annual performance goals were achieved (green). As the table shows, we continued the solicitation of customer feedback on our services, facilities, and expertise, and the implementation and establishment of current and new education outreach plans.

| Strategic Goal 4. Enable, and as appropriate provide, on a National basis, world-class aerospace research and development (R&D) services, including facilities and expertise | | |
|---|---|---|
| **APG** | **Description** | **Assessment** |
| 1R12 | Continue the solicitation of customer feedback on the services, facilities and expertise provided by the Aerospace Technology Enterprise; indicators include two customer survey instruments utilized by the Aerospace Technology Enterprise, along with documented cases of new technologies transferred to industry and other government agencies. | Green |
| 1R13 | Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 01; indicators include examples of educational outreach activities for current plans and the planning documentation for new programs. | Green |

## Trends

NASA completed both of its planned goals in enabling and providing on a national basis, world-class aerospace research and development services. This represents an increase from FY 2000, with a 75-percent achievement rate (blue and green), and FY 1999, with a 67-percent achievement rate.




Performance in achieving the strategic goal of enabling world-class aerospace research and development services increased in FY 2001.

## Awards, Honors, and Distinctions

NASA received numerous awards and honors in FY 2001. For example, the NASA Ames Rotorcraft program was awarded the FY 2001 Harry T. Jenson award for its work in the prediction of rotorcraft crashworthiness. The National Aeronautic Association selected Dryden Research Center's 96,863-foot record setting flight of Helios as one of the most memorable records of FY 2001. This record is pending certification by the Fédération Aéronautique Internationale. The Glenn Research Center's Rotor Alone Nacelle team was awarded the 2001 Szabo Award for Engineering Excellence, acknowledging its outstanding contributions to engineering design. The Glenn Research Center's Propulsion and Power Program (Higher Operating Temperature Propulsion Components project) received a First Place award in the competition at the 26th Annual Conference on Composites, Materials, and Structures. The Glenn Research Center's Numerical Propulsion System Simulation was recognized as NASA's software of the year and recognized as 1 of the top 15 "Quality Software Projects" in 2001 by the *Journal of Defense Software Engineering*.

Two flight research projects at NASA's Dryden Flight Research Center have each received a "Best of What's New" award from *Popular Science* magazine. The two projects include the solar-powered Helios flying wing that set a world's record in summer 2001, and the I-2000 Inflatable Wing technology demonstration aircraft.

## Partnerships

As the Agency's lead for technology development, the Aerospace Technology Enterprise has established a number of partnerships with other Federal agencies, other NASA enterprises, industry, and universities. The aim is to develop technologies for their needs and transition these technologies into commercial, NASA, and military applications. For example, the Federal Aviation Administration and the U.S. Department of Defense are working closely with NASA to develop technologies that will improve the safety, performance and efficiency of current and future generations of aviation and airspace systems. A close working relationship eliminates potential duplication and results in a synergistic process that allows the technology to be expeditiously transferred to the customer. In addition to the aviation technology program, NASA is also working closely with the U.S. Department of Defense in developing the next generation of launch vehicles. A study is underway to identify common technology needs and establish a coordinated research and technology development program. This will eliminate duplication and allow the needs of both organizations to be met in a timely fashion. The Aerospace Technology enterprise develops the advanced technologies that other NASA enterprises will need for future missions. A key part of this arrangement is the development of jointly-funded programs between coordinating enterprises for the maturation of promising technologies to the point that they can be incorporated in future NASA missions. These advanced technologies will provide scientific information that is currently unavailable. NASA also is working closely with industry to mature and quickly transition NASA-developed technology from the laboratory into production. A good example of this close cooperation was the transition of the NASA-developed low-nitrogen oxide combustor technology into production in less than 1 year. NASA also took first steps in establishing research, education, and training institutes at leading U.S. universities.

# *NASA's Crosscutting Processes*

# Manage Strategically

*NASA manages strategically to ensure that we carry out our responsibilities effectively, efficiently, and safely through sound management decisions and practices. By integrating general management practices with our strategic course of action, we can proceed together—coherently, comprehensively, and expeditiously toward the achievement of a single set of strategic goals. We must leverage limited resources, standardize procedures where it makes sense to do so, streamline methods for timely results, and ensure rapid, reliable, and open exchange of information.*

# Manage Strategically

## Strategic Goal

The Manage Strategically goal is to ensure that the Agency carries out its responsibilities effectively, efficiently, and safely through sound management decisions and practices as it allocates its resources to support NASA's strategic, implementation, and performance plans.

### Achievements

#### *Workforce and Infrastructure Safety*

Safety is a top priority at NASA. A number of NASA personnel work in hazardous environments. Accidents or failures in NASA technical facilities, aircraft, and space-based assets could place Agency personnel and programs at risk. In NASA's safety hierarchy, public safety comes first. Second, the Agency must ensure that the astronauts and pilots who serve under hazardous conditions are not exposed to more risk than necessary. Third, NASA must provide its ground-based workforce with a safe, healthy workplace. Finally, as a steward of the public trust, the Agency must protect high-value property and equipment.

To determine the extent to which a culture of safety exists, NASA conducts annual Performance Evaluation Profile surveys to assess occupational safety and health programs within the Agency. In FY 2001, both employee and manager scores increased over FY 1999 scores. (Manager scores reached Level 4, which indicates that superior safety and health programs are in place.) In addition, the overall occurrence of occupational injuries and illness decreased to 0.75 occurrences for every 100 workers, well below the government goal of 1.19 occurrences per 100 workers.

**NASA makes safety a top priority in Agency facilities**

In many NASA facilities, employees must work under demanding conditions. Here, hot-fire engine tests are conducted at the Stennis Space Center in Mississippi. Placing safety first not only ensures employee and public safety, but also ensures that accidents and failures do not impede mission success.

NASA's concern for safety extends to the environment as a whole. Through the Environmental Compliance and Restoration Program, NASA stresses cleaning up all contaminated sites as rapidly as possible. In this effort, NASA's environmental managers obligated \$20.9 million to projects impacting the Agency's environmental liability.

In the area of environmental mishaps, NASA decreased the number of spill incidents by 20 percent. The numbers of overall environmental mishaps were level between FY 2000 and FY 2001 at 218.

#### *Contract Management*

For the past 10 years, NASA's procurement obligations have accounted for more than 87 percent of the Agency's total fiscal obligations. Effective management at NASA, therefore, depends on effective contract management. To increase return on investment, NASA has steadily increased the percentage of contract dollars obligated on performance-based contracts. In FY 2001, performance-based contracts increased to 86 percent against a goal of 80 percent of funds available for performance-based contracts (up from less than 50 percent in FY 1995).

NASA also continued to expand the industrial base needed for such extensive contract support. Legislation enacted in 1990 requires that Federal agencies award 8 percent of their total annual prime and subcontract dollars to small disadvantaged businesses, including women-owned businesses, historically black colleges and universities, and other minority educational institutions. Continuing the upward progress marked since these laws were passed in 1990, NASA awarded approximately 19 percent of its contract dollars to these businesses and institutions in FY 2001.

*Competitive Sourcing*

Competitive Sourcing is one of the five government-wide initiatives from President Bush's Management Agenda, which was developed in 2001. In the President's FY 2003 budget, released in February 2002, NASA received a "red" assessment in this area, but the Agency is taking steps to correct this, including updating the Agency's inventory of which NASA positions are not inherently governmental and developing and implementing a plan to compete a greater percentage of those positions. NASA is also exploring the competitive sourcing of Shuttle operations, and utilizing a nongovernmental organization to manage Space Station research.

*Facilities, Management Systems, and Human Resource Renewal*

Facilities

NASA is more than 4 decades old, and some of its facilities date back to much older predecessor organizations. NASA must ensure that these facilities, as well as more recent additions, continue to function safely and effectively. To determine how many years it would take to completely revitalize a physical plant at current funding levels, NASA uses a facilities revitalization metric. The goal of 100 years represents the minimum facilities revitalization investment necessary to prevent NASA from reaching the point of unsafe operations of a physical plant. Reducing the facilities revitalization frequency reduces the probability of further backlogs and deterioration of NASA's physical plant. As a result of increased funding for critical safety projects identified in a facility safety assessment, NASA decreased its FY 2001 facilities revitalization frequency to 96 years from the FY 1999 baseline of 147 years.

**NASA's research facilities withstand the test of time**

A technician prepares to unlatch the door built into the guide vanes of the 16-Foot Transonic Wind Tunnel at NASA Langley Research Center, Hampton, Virginia. The tunnel, one of dozens of research facilities at Langley, was built in 1939 and most recently renovated in 1990.

Management Systems

NASA takes seriously its responsibility to manage its financial resources to protect the public's investment. In FY 2001, NASA resolved outstanding issues related to certain accounting transactions that obligate and deobligate funds, a concern raised in the NASA Inspector General's report on management challenges.

During the fall of 2000, NASA totally restructured its approach to implementing an integrated financial management system. After encountering serious software design problems and repeated delays, NASA terminated its contract with the incumbent system developer. A new integrated financial management system remains a high priority, and a new effort has resulted in a significantly modified program concept based on benchmarks in both the commercial and Federal sectors. Improved financial management is one of the five major initiatives on the President's Management Agenda. NASA received a "yellow" assessment in this area, but the Core Financial Module of the new Integrated Financial Management Program is on schedule to begin deployment in FY 2002, and to be fully deployed by June 2003. The Agency has also accelerated the schedule for other modules in the system.

Human Resource Renewal

From January 1993 to January 2000, the Federal government civilian workforce was reduced by 384,000 employees. Many of those who left were among the most experienced professionals in their agencies. Even as the workforce became smaller, new responsibilities and new ways of doing existing work demanded new skills. Additional skill losses are still occurring as an entire generation approaches retirement eligibility. For a number of reasons, the Federal government is not attracting the skills required to participate in the Information Age, and for the second consecutive year, Federal Chief Information Officers identified the need for skilled information technology workers as their most critical issue.

As a Federal research and development agency, NASA faces even greater challenges in recruiting and maintaining the high quality, diverse civil service workforce it needs now and in the future. NASA has downsized its civil service workforce from nearly 25,000 to less than 19,000 over the last 9 years. Since 1995, for example, the Space Shuttle workforce has decreased by more than one third, and several NASA internal studies have shown that downsizing has negatively effected the Agency's skill mix for this and other programs. Moreover, the Shuttle program's demographic distribution and skill mix jeopardize the program's ability to hand-off leadership roles to the next generation and achieve the necessary staffing to support the International Space Station. To address these challenges, NASA discontinued downsizing and hired a limited number of additional personnel.

The strategic management of human capital remains a top priority for NASA, particularly since human capital is one of the five major initiatives on the President's Management Agenda. NASA recently received a score of "red" in this area, but the Agency is responding to this challenge by improving recruitment and retention, training, career development, and workforce planning.

### Recruitment and Retention

To be competitive with other employers, NASA must have a continuing presence on college and university campuses. NASA Centers are reestablishing recruitment networks and rebuilding the once extensive NASA Co-operative Education Program. The Agency is also continuing to take advantage of the Presidential Management Intern Program and student employment programs as sources for entry-level personnel.

In December 2000, Federal agencies were given the authority to establish their own Federal Career Intern Programs as a means of recruiting individuals into developmental positions at the General Schedule 5, 7, or 9 levels. These regulations allow for much greater flexibility in the hiring and examining processes than the traditional Federal hiring authorities. NASA designed plans that promote flexible and expeditious recruitment processes that can compete more successfully with the hiring practices of the private sector. In fact, NASA was one of the first Federal agencies to hire individuals under this program and, based on its initial success, NASA anticipates that it will be a useful tool for hiring new graduates with engineering and science degrees.

In 2001, NASA established the National Recruitment Initiative to develop Agency-wide strategies to attract and hire a highly technical workforce, focusing on recent graduates to counterbalance an aging workforce. NASA also initiated the automated Staffing and Recruitment System, a pathfinder project under the Integrated Financial Management Program. The Staffing and Recruitment System is an automated resume management process that uses a computer-assisted rating and referral system to simplify and expedite hiring. It allows applicants to apply on-line and enables the creation of a skills database.

NASA's programs excite the imagination, and the Agency has been able to attract people eager to be a part of the Agency's mission. However, financial considerations play an important role when recruiting potential candidates. Therefore, NASA Centers increased their use of hiring authorities that enable them to offer starting salaries above the minimum rate of a General Schedule grade or to offer retention allowances to attract and retain the best and brightest employees. The Agency expects this trend to continue because of an increasingly competitive job market and the high cost of living in areas surrounding some NASA facilities.

Beginning in August 2001, NASA Centers also began the practice of repaying student loans to attract or retain employees. NASA was the first agency to implement this new Federal program. To be eligible for student loan repayment benefits, an employee must agree to remain with NASA for a specified period, no less than 3 years.

### *Training, Career Development, and Succession Planning*

As important as it is to attract and retain the right people, it is equally vital to provide training and development opportunities for the current workforce. In FY 2001, NASA implemented the first year of a multi-year plan to increase its investment in the development of the NASA workforce. The increased funding enabled NASA to address challenges associated with reductions in the total workforce, skill mix issues, and the overall aging of the workforce.

NASA is emphasizing "just in time" training opportunities for project leaders and team members to improve project team competencies. The Agency is also pursuing learning through simulations, as well as coaching and mentoring opportunities. The largest FY 2001 investment in employee development went to creating and implementing additional on-line training. The FY 2001 products included 11 new on-line courses on NASA's Site for Online Learning and Resources; the development of an interactive project management simulation based on the "better, faster, cheaper" Mars Pathfinder mission; and the initiation of an on-line journal, *Academy Sharing Knowledge*, that shares lessons in project management learned by NASA practitioners. In addition, a number of individual and team assessment tools were developed and hosted on both the NASA Leadership and the Academy of Program and Project Leadership web sites.

Information Technology Workforce Initiatives

In 1999, the NASA Chief Information Officer established an Agency-wide Information Technology Workforce Program Team. In FY 2001, the team assessed the information technology skills and knowledge of NASA's senior and executive information technology managers through a survey. The results revealed a need for succession planning to ensure that NASA has a skilled and knowledgeable cadre of senior and executive information technology managers. To accomplish this goal, NASA initiated a pilot training effort. In July 2001, over 20 senior and executive information technology managers participated in a Carnegie Mellon University 1-week executive level survey course based on the Clinger-Cohen Act Core Competencies learning objectives. The Chief Information Officer also established a Chief Information Officer University Professional Development Program Position, to provide an opportunity for 1-year developmental assignments.

**NASA summer intern studies microgravity effects**

A high school student working at NASA Glenn Research Center as a 2001 summer intern describes her job as "…very interesting and enjoyable. Half of the time I am working with a scientist that I am assigned to. We work mostly down in the lab and on the computers analyzing our experiment results. The experiments with pool boiling are being used to try to create a method to be able to boil liquids in a microgravity environment. Working with a scientist and college interns is a very rewarding experience. I have learned an incredible amount from working with them for only a few weeks. The other half of the time I am here, I work with the educational support program."

In addition, NASA implemented a number of special initiatives to attract information technology professionals. The Agency implemented special salary rates for information technology occupations, effective January 1, 2001; continued its participation in the Office of Personnel Management-led information technology pilot of the new Information Technology Classification Standard; and developed and implemented a new NASA qualification standard for cooperative education student-employees.

Future Pipeline

NASA continues to look for ways to help ensure a pipeline of emerging talent. The new Agency-wide Undergraduate Student Research Program began its pilot phase in FY 2001 with 107 students. The program provides students opportunities for participating in research and gaining experience in their chosen disciplines. It 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. It will also build a national program bridge from existing NASA kindergarten through high school 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.

## *Information Technology Infrastructure*

Service Delivery

E-Government is one of the five major initiatives on the President's Management Agenda. In the President's FY 2003 budget, NASA received a "red" assessment in this area, but the Agency is developing plans to strengthen management of its information technology infrastructure as a NASA-wide strategic asset, to further modernize its infrastructure to support modern applications, and to create shared services to improve web management and virtual teaming capabilities.

Internet Use

In FY 2001, NASA increased its use of Internet technologies to improve productivity and customer satisfaction. Examples include:

- Automated Computer User Registration Form, a software system for web-based user registration and access control for USA (United Space Alliance), the Space Flight Operations Contractor
- NASA Environmental Tracking System, a web-based, user-friendly system to collect, aggregate, analyze, and report Agency-level environmental information
- NASA Integrated Technical Standard Initiative, an integrated web site for information on Agency technical standards
- Web Enabled Ordering for desktop services and information collection
- Insight System, a web-enabled database tool by which the government obtains the insight needed to effectively assess contractor performance.

Computer Dependability

In FY 2001, NASA and Carnegie Mellon University officials announced the formation of a new High Dependability Computing Consortium whose mission is to eliminate failures in computing systems critical to the welfare of society.

Scientific and Technical Application Development

Understanding the essential role that software systems play in mission success, NASA developed or deployed a wide variety of notable scientific/engineering applications during FY 2001. These included:

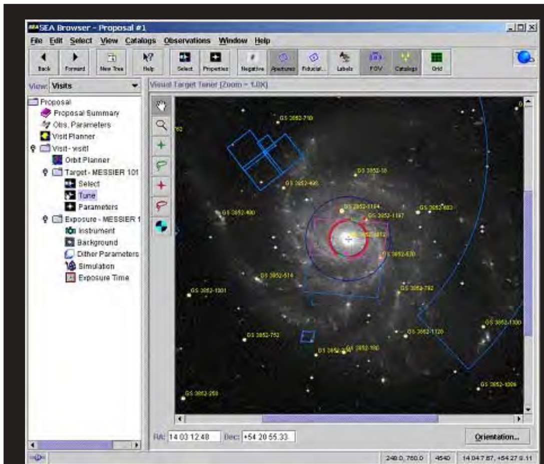
- Internet-based Global Differential Global Positioning System for real-time positioning and orbit determination
- A software application ("DIRECT") for a fast assessment of the structural integrity of space vehicles and payloads

- Future Air Traffic Concepts Evaluation Tool
- Control Designer's Unified Interface for the rapid modeling and analysis of flight control systems for new aircraft
- Live video mission support server for payload development at remote locations
- Virtual reality exploration laboratory for scientific research and education
- Distributed Object Visualization Environment for quick and easy visualization and analysis of scientific data
- Software process improvement using the Software Capability Maturity Model

Innovative Software Development

Each year, the Agency co-sponsors the NASA Software of the Year Competition to encourage development of innovative quality software that has high potential for use and reuse across NASA and for commercialization in the private sector. The NASA Software of the Year Award for 2001 was shared between two winners:

- The Numerical Propulsion System Simulation, submitted by the NASA Glenn Research Center, is a world-class propulsion system simulation tool that provides the user with unprecedented capability and ease of use. It provides NASA and the U.S. aerospace industry with a revolutionary engineering capability that will reduce the cost and risk associated with advanced propulsion system development.
- The Generalized Fluid System Simulation Program, submitted by the NASA Marshall Space Flight Center, is a computer program capable of modeling phase changes, compressibility, mixture thermodynamics, and external body forces with subroutines for computing real fluid thermodynamic and thermophysical properties for 33 fluids. The program is such a significant design and research aid that potential licensees are in negotiation with NASA for its commercial use and a patent is pending.



**Scientist's Expert Assistant wins honorable mention**

The NASA Software Advisory Panel recently awarded an Honorable Mention in the 2001 NASA Software of the Year award competition to the Scientist's Expert Assistant, a software tool that enables scientists to visually and interactively develop valid observational proposals. It allows the scientist to effectively determine the likely quality of the observations, and reduce the number of unusable observations. Historically, observatories have provided significant staffing to help observers develop their observing proposals. This is a manually intensive, and therefore costly, effort. In order to meet the operational cost objectives for the Next Generation Space Telescope, this process needs to be dramatically less time consuming and less costly. The goals and philosophies used in developing Scientist's Expert Assistant have attempted to make the user more self-sufficient and hence minimize manual effort and cost for user support.

Information Technology Security

NASA engineers designed, tested, and approved a portion of the Agency's information technology network with a partitioned firewall to serve as an area to implement riskier requirement configurations. This allows each NASA Center to secure its data and Information Technology infrastructure according to Agency and Federal laws without interfering with ongoing programs.

*Information Technology Security Training*

In FY 2001, NASA developed and implemented web-based Information Technology Security training modules to achieve a trained workforce of users, managers, system/network administrators, and information technology security managers. The web-based delivery system enables employees to take information technology security training at their desks. NASA also established a core skill set of elements for Center information technology security managers and requires training in two of those elements each year.

*Vulnerability Reduction*

In FY 2001, NASA's Principal Center for Information Technology Security, the Ames Research Center, selected three NASA Centers for a third party review of the Centers' information technology security programs, including penetration testing from both an outside and inside perspective. All Centers will be scheduled for a review and penetration test about every 3 years. The Principal Center for Information Technology Security also conducted tests of the Agency's after-hours Emergency Notification Process to ensure quick response to hostile activities. In FY 2001, NASA also expanded its Vulnerability Reduction Program to address complex vulnerabilities, identified by both outside experts and NASA's in-house information technology security community.

*Authentication and Data Protection*

During FY 2001, NASA addressed user authentication and data protection activities to better secure its operating and information systems. The Agency conducted a self-assessment of systems' contingency plans and adopted step-by-step guidelines for securely configuring the Agency's major operating systems. NASA also identified functions required to protect data from disclosure and began a program to ensure all employees have the capability to protect that data. The Agency also developed a public key infrastructure capability to enable digital signature, authentication, and encryption in support of secure electronic messaging, the Integrated Financial Management Program, and electronic commerce initiatives.

In FY 2001, NASA also purchased smart card and token technologies for pilot evaluations and integration into virtual private network capabilities and remote access services. NASA information technology security services will utilize these tools to provide secure access via Internet connections and will audit required patches that have been installed. This technology also will enable NASA to identify other vulnerabilities and to initiate corrective action.

*Intrusion Detection*

To further enhance the Agency's information technology incident detection and response capability, NASA implemented a Critical Infrastructure Protection Program. This effort focuses on ensuring that adequate security is provided for NASA's Minimum Essential Infrastructure assets in a cost-effective and efficient manner. During FY 2001, NASA assembled an initial list of all Minimal Essential Infrastructure assets and completed information technology security assessments. In addition, the Agency developed and began implementation of mitigation plans to eliminate serious security vulnerabilities.

Challenges

*Safety*

NASA created an indicator of how quickly NASA is progressing in mitigating facility safety issues. In FY 2001, NASA awarded 60 of the 64 (94 percent) construction contracts planned to improve safety requirements in critical facilities. However, the Agency continues to press for the awarding of 100 percent of planned contracts for critical safety projects to reduce safety risks and reinforce the Agency's commitment to eliminating lost time incidents.

*Human Resources*

While NASA has increased representation of women and minorities since FY 1999, in FY 2001, the Agency did not achieve the targeted increases in workforce diversity levels. The percentage of individuals in the NASA workforce with targeted disabilities has remained about the same since FY 1999.

In addition, the Agency's science and engineering pipeline is in jeopardy. Over and above the effects of downsizing and an aging workforce, universities have reported reduced student enrollment in science and engineering courses, which points to a critical future shortage that will pose a challenging recruiting environment for NASA.

Early findings from NASA's ongoing review of strategic resources point to critical skill gaps between what the Agency has and what the Agency needs. The gaps include expertise in nanotechnology, systems engineering, liquid propulsion systems, and advanced information technology (artificial intelligence, neural nets, autonomy and robotics, automated software, collaborative and assistant systems, super-computing technologies) as well as astrobiology, biotechnology, advanced materials, information science (data archiving), Earth systems science, and space science. NASA is developing a more comprehensive picture of the Agency's skills needs. However, the challenge of attracting and retaining persons with the needed skills is already clear.

In FY 2002, the Agency will begin the process of replacing individual Center workforce planning and reporting systems with a consistent, Agency-wide workforce planning and reporting system. In years to come, this will enable Centers to plan recruitment, retention, training, succession, and career development activities that are tailored to their individual circumstances while supporting Agency goals and objectives.

*Information Technology*

In the preceding fiscal year, the NASA Inspector General's investigations, audits, and inspections continued to report a fragmented information technology security program, without clear lines of authority, policies, guidelines, and enforcement. A primary concern was that NASA continues to maintain separate organizations to handle security for classified and unclassified information technology systems. NASA continues to respond to these concerns with system and process improvements. However, given the extent of our systems, as well as the magnitude and variety of security threats, our security program remains a key challenge.

## Assessments

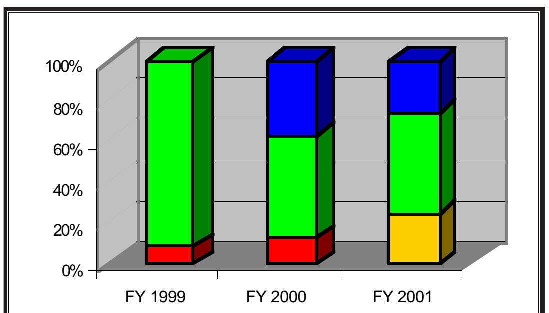
As the table shows, three of the four annual performance goals were fully achieved or exceeded (blue and green). We were successful in achieving annual performance goals associated with contract management; facility, management system, and human resource revitalization; and information technology infrastructure improvement. In FY 2001, we developed new metrics to track safety, environmental, and facility renewal improvements. Three of these performance indicators were substantially achieved but did not meet the strict definition of the metric. These resulted in "yellow" for annual performance goal 1MS1.

**Strategic Goal. Ensure that the Agency meets its responsibilities safely and effectively, as it allocates its resources to support NASA's strategic, implementation, and performance plans**

| APG | Description | Assessment |
|---|---|---|
| 1MS1 | 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 five 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), and maintain significant contractor involvement in NASA programs for small businesses, minority institutions, and minority and women owned businesses by meeting 2 out of 2 performance indicators in this area. | |
| 1MS3 | Renew Agency 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. | |
| 1MS4 | Improve Information Technology infrastructure service delivery to provide increased capability and efficiency while maintaining a customer rating of satisfactory, and enhance Information Technology security through a reduction of system vulnerabilities across all NASA centers, emphasizing Information Technology security awareness training for all NASA personnel by meeting 2 out of 2 performance indicators in this area. | |

## Trends

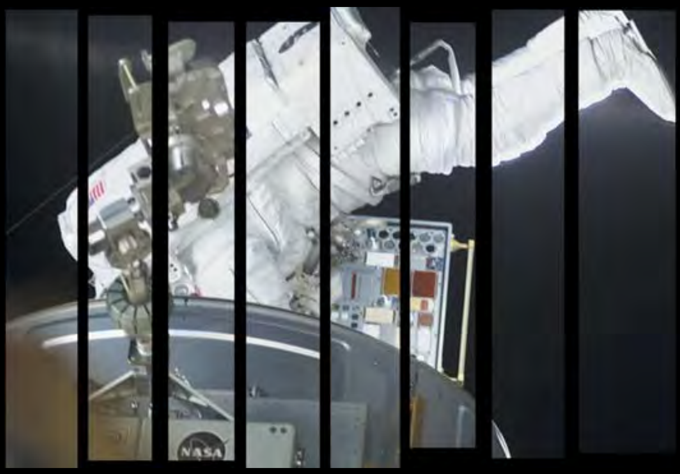
As the graph shows, there are two indications that performance is showing signs of improvement. First, there were no annual performance goals considered to be unfeasible or unachievable (red). Second, in the last two fiscal years, a substantial percentage of annual performance goals were not only achieved (green), but also exceeded (blue). In fact, the combined total of goals achieved and/or exceeded reached 92 percent in FY 1999, 88 percent in FY 2000, and 75 percent FY 2001.




Annual performance goal achievement in ensuring that the Agency meets its responsibilities safely and effectively was 75 percent in FY 2001.

# Generate Knowledge

*NASA generates new scientific and technological knowledge gained from exploring the Earth system, the solar system, and the universe beyond, and from conducting the necessary supporting research and development. We share this information with scientists, engineers, and technologists in industry, academia, and other organizations. In addition, natural resource managers, policymakers, and educators benefit from these efforts. Our goals are to extend the boundaries of knowledge of science, technology, and engineering; to capture new knowledge in useful and transferable media; and to share new knowledge with customers. The Agency's three scientific research organizations, Space Science, Earth Science, and Biological and Physical Research, work together to achieve the goals of generating knowledge. Not included is research of a proprietary industrial nature or research whose conduct or dissemination is limited for reasons of national security.*



# Generate Knowledge

**Strategic Goal**

The Generate Knowledge goal is to extend the boundaries of knowledge in science and engineering, to capture new knowledge in useful and transferable media, and to share new knowledge with customers.

Achievements

NASA provides new scientific and technical knowledge gained from exploring the Earth system; the solar system and the universe; and from researching biological, chemical, and physical processes in the space environment. NASA's missions and programs offer opportunities to conduct research using unique platforms, such as aircraft, spacecraft, and sounding rockets. The information acquired from our research is useful to scientists, engineers, technologists, natural resource managers, policymakers, educators, and the general public. Through this process, the Agency ensures that the science and technology efforts funded by NASA are of the highest caliber.

*Letters of Advice*

In FY 2001, the enterprises continued to acquire advice through their advisory committees, all of which met on schedule and collectively submitted seven letters of advice to the Agency as planned.

*Competitive Merit Reviews*

The Agency continued to select and fund its research by means of merit review. For the last 3 years, NASA has peer reviewed at least 80 percent of its research funds. In addition, the Agency increased the number of principal investigators from 3,184 to 3,535. Interest in space missions increased during the period between FY 1999 and FY 2001, based on the increase of researchers proposing experiments and getting funded. The Agency is currently funding innovative research for the International Space Station, which became the primary space-based research platform in FY 2001.

**NASA uses the space station exterior to study space effects**

During a space walk, a NASA astronaut installs the first experiment on the outside of the International Space Station. The Materials International Space Station Experiment will expose hundreds of samples to the space environment for about 18 months. When the samples are returned to Earth, they will be analyzed by scientists from the materials laboratory at NASA's Marshall Space Flight Center in Huntsville, Alabama, as well as by scientists from industry, other government institutions and NASA Centers, to determine which materials are the most durable and suitable for tomorrow's spacecraft.

*Data Accessibility*

Data archiving is very important to NASA, as we document the history of the Agency and enable preparations for the future. Space flight data are unique and missions are expensive; therefore, the Agency takes data archiving very seriously. Each year, the Agency creates a goal for data archiving to ensure the proper storage of mission information. In FY 2001, the Agency met all of its goals for archiving data from its active missions.

## Challenges

In order to plan and set research priorities, NASA must ensure the development and/or release of updated Enterprise strategic plans. In FY 2001, this objective was not fully met. Although the Space Science and Earth Science Enterprises released updated products, the Human Exploration and Development of Space Enterprise and the newly formed Biological and Physical Research Enterprise were unable to produce an updated plan before the end of the fiscal year. The Biological and Physical Research Enterprise delay was due to the fluidity of the International Space Station program with regard to research. Human Exploration and Development of Space completed an unofficial update to the plan; however, in order to meet the goal an official update was required.

## Assessments

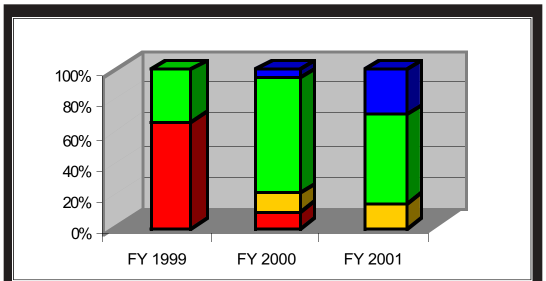
In FY 2001, we identified activities that acquire advice; plan and set research priorities; select, fund, and conduct research program tasks; archive, publish, and patent data, as well as share the results; and collaborate with old and new partners. Out of the seven annual performance goals, the assessments are as follows: two blue, four green, and one yellow.

**Strategic Goal. Extend the boundaries of knowledge of science and engineering, to capture new knowledge in useful and transferable media, and to share new knowledge with customers**

| APG | Description | Assessment |
|---|---|---|
| 1G1 | NASA will obtain at least 7 letters of advice through the Enterprise advisory committees. | |
| 1G2 | The Space Science Enterprise, the Earth Science Enterprise, and Office of Life and Microgravity Science Applications (OLMSA)/Human Exploration and Development of Space (HEDS) will develop and/or release updated enterprise strategic plans. NASA will meet at least 2 out of 3 of the indicators for this annual performance goal. | |
| 1G3 | The Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS will use competitive merit review wherever possible to select performers for science and basic technology research. NASA will meet at least 2 out of 3 of the indicators for this annual performance goal. | |
| 1G4 | The Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS will achieve all 3 indicators results of disseminating results of their research to a diverse population of users via the internet and publications. | |
| 1G5 | The Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS will make science data obtained widely accessible as soon as possible after receipt and will maintain these data in open archives. NASA will meet the two indicators for this annual performance goal. | |
| 1G6 | NASA will work with other federal agencies and U.S. industry to complement and support our activities. This will be measured by renewing Memoranda of Understanding (MOUs) and Memoranda of Agreement (MOAs) with our partners and opening new areas of cooperation via the same mechanisms. | |
| 1G7 | Pursue new, mutually beneficial cooperative activities in aeronautics and space with other nations. This will be measured by the initiation of new Letters of Agreement (LOAs) and MOUs with our partners. | |

## Trends

In FY 2001, the annual performance goal achievement in extending the boundaries of knowledge of science and engineering, capturing new knowledge in useful and transferable media, and sharing new knowledge with customers was 86 percent (blue and green). This represents an increase from FY 2000, when 79 percent of the annual performance goals were achieved, and FY 1999, when only 33 percent of the annual performance goals were achieved. NASA expects the remaining 14 percent (yellow) of the FY 2001 annual performance goals to be achieved within the next fiscal year.



Overall FY 2001 goal achievement showed an increase (blue and green) to 86 percent, compared to 79 percent in FY 2000, and 33 percent in FY 1999.

## Awards, Honors, and Distinctions

NASA and NASA-funded research is recognized the world over. Specific awards in FY 2001 are described in the Space Science, Earth Science, and Biological and Physical Research Enterprise sections of this report. They include the prestigious Heinz Award for work on global climate warming, and the Nobel Prize in Physics for work on Bose-Einstein condensates, a new state of matter in which individual atoms merge into each other.

### Disseminating Research Results

This process captures the percentage of the most important stories that NASA funded in the annual review by *Science News*. For the stories reported in Calendar Year 2000, the Space Science Enterprise accounted for over 4 percent of worldwide discoveries, and the Earth Science Enterprise accounted for 3 percent of the discoveries, bringing the NASA total to over 7 percent, the best overall performance since 1996. *Science News* performs this survey of stories in the second quarter of the fiscal year (in this case, FY 2001) and it reflects the accomplishments of the calendar year.

### Other Disseminating Research Results

Data from the Hubble Space Telescope were used to determine that intergalactic hydrogen is increasing and that the expansion of the universe is accelerating. Data from the Chandra X-Ray Observatory were used to find intermediate-sized black holes and identify sources of diffuse x-ray background radiation in Chandra Deep Fields. Both Chandra and Hubble data helped scientists determine that supermassive black holes at galactic cores are far more numerous than visible light surveys had detected. Other exciting discoveries made with Galileo and the Mars Global Surveyor spacecraft contributed to scientific knowledge. These spacecraft provided possible evidence of water on Mars, Europa, and Ganymede. The Earth Science Enterprise projects contributed to the generation of knowledge with stories on the effective use of world-wide assets, such as the Global Positioning System, Defense Meteorological Satellite Program, and National Oceanic and Atmospheric Administration weather satellites. In addition, there were contributions from aircraft (arctic ozone, Greenland ice sheet); the Topography Experiment Poseidon satellite (North Pacific); the Terra satellite (snow cover, Ross Ice Shelf); the Tropical Rainfall Measuring Mission (pollution and rainfall); and the Upper Atmosphere Research Satellite (arctic ozone). From these missions, research results are produced and disseminated.

## NASA participates in an effort to advance the science of climate change

**An example of why NASA enters into partnerships**

For Immediate Release
Office of the Press Secretary
July 13, 2001

Statement by the President

Last month, I announced the fundamental principles to guide a scientifically sound and effective global effort to reduce the buildup of greenhouse gases in the atmosphere. As I said then, my Administration's climate change policy will be science-based, encourage research breakthroughs that lead to technological innovation, and take advantage of the power of markets. It will encourage global participation and will pursue actions that will help ensure continued economic growth and prosperity for our citizens and for citizens throughout the world.

Today I am pleased to report on specific initiatives that have been advanced in the past month by my Cabinet-level climate change working group. These initiatives represent important steps in putting our principles to work through partnerships with other nations, industry and non-governmental organizations. They are designed to increase our scientific understanding of climate change, to tap the enormous promise of technology in addressing greenhouse gas emissions, and to promote further cooperation on climate change with our partners in the Western Hemisphere and beyond.

To advance the science of climate change, the Secretary of Commerce has convened an interagency work group charged with developing a federal research plan that will prove vital to increasing our understanding of the dimensions and dynamics of climate change. Prominently, NASA will invest over $120 million in the next three years in research on the natural carbon cycle, climate modeling, and the link between atmospheric chemistry and climate to help reduce uncertainties in the science highlighted by the recent National Academy of Sciences report requested by my Cabinet-level working group.

To advance technological innovation, the Department of Energy has just signed agreements to begin two significant new projects to study carbon sequestration. The first agreement is with The Nature Conservancy, the world's largest private international conservation group, to study land use and forestry practices for storing carbon more effectively in Brazil and Belize. The second is with an international team of energy companies—BP-Amoco, Shell, Chevron, Texaco, Pan Canadian (Canada), Suncor Energy (Canada), ENI (Italy), Statoil Forskningssenter (Norway) and Norsk Hydro (Norway)—to develop a new set of technologies for reducing the cost of capturing carbon dioxide from fossil fuel combustion plants. Grants for six other sequestration research projects have also been awarded under this $25 million initiative that leverages an additional $50 million from the private sector and foreign governments.

To further cooperation in the Western Hemisphere and beyond on climate change, the Department of Treasury yesterday entered into a $14 million "debt for forest" agreement with the Government of El Salvador under the Tropical Forest Conservation Act. By funding tropical forest conservation in that country, the agreement will secure important benefits of carbon sequestration and climate change mitigation.

Fostering further scientific cooperation on climate change among nations in our hemisphere, the Department of Commerce is bringing together more than one hundred scientists from the United States, Mexico and South America to study the regional impacts of climate change, another important area of uncertainty highlighted by the National Academy of Sciences study.

My Environmental Protection Agency Administrator also met with the Canadian and Mexican environment ministers on June 29 and pledged to jointly consider "market-based approaches for carbon sequestration, energy efficiency and renewable energy in North America." Today, the United States will host a meeting with the Japanese Environment Minister at which they will focus on opportunities for bilateral cooperation on climate change, including enhanced, joint climate modeling research.

Finally, in keeping with my commitment to engage internationally, the United States has participated and will continue to participate constructively in international discussions on climate change, including in the upcoming Sixth Conference of the Parties to the Framework Convention on Climate Change (COP-6) that begins this Monday in Bonn, Germany.

These initiatives illustrate the efforts my Administration will continue to encourage strongly. These partnerships leverage resources to achieve tangible results. In many cases, their scope is international, reflecting the fact that both the problem and solutions for climate change extend beyond the borders of any one nation. And they represent the kind of investments in scientific and technological knowledge on which real progress on this long-term challenge must be based. I am pleased that those who are signing agreements with us or who have otherwise pledged to pursue joint research with our government share our vision of enhancing our knowledge and making progress on this important issue.

## Partnerships

### Federal and Industry Partnerships

The final count of Memoranda of Agreement and Letters of Agreement finalized by the Agency in FY 2001 greatly exceeded all expectations. Five of the most promising memoranda signed this year include the Memoranda of Understanding with the National Institute on Deafness and Other Communication Disorders, the Lawrence Berkeley Laboratory, the National Institute on Neurological Disorders and Stroke, the National Cancer Institute, and the Federal Emergency Management Agency. This last agreement dealt with work in disaster mitigation and preparedness activities, including mapping of potential earthquake sites.

### International Partnerships

Because of the total cost and uniqueness of NASA's missions, it is imperative that the Agency leverages its resources with those of other Federal agencies, industry and international partners. NASA continuously collaborates with new and old partners. FY 2001 progress in establishing Federal, commercial, and international partnerships was successful.

Agreements with international partners were also plentiful. In FY 2001, NASA concluded over 80 international agreements with 30 countries and international organizations in support of the Enterprises, for space education activities, or to establish a framework for subsequent arrangements. These include Memoranda of Understanding for significant international cooperation and Letters of Agreement for visiting researchers, data analysis, ground-based projects, and other cooperation with foreign entities. It must be noted that very few Memoranda of Understanding for significant international cooperation are concluded each fiscal year. However, numerous Letters of Agreement are required to complete nominal operations for the Agency. The great number of agreements completed in FY 2001 is a good indication of the Agency's leveraging with other agencies, both domestic and international.

# Communicate Knowledge

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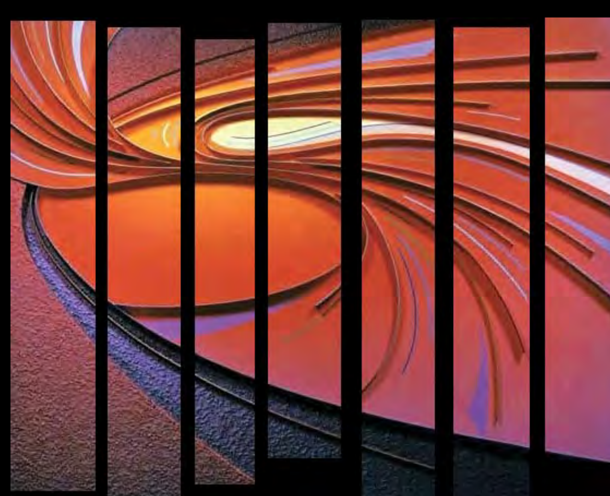
*NASA communicates knowledge by distributing information from our missions and discoveries. We ensure increased public understanding of science and technology, promote the application of NASA-generated information, and inspire achievement and innovation. We make certain that knowledge derived from our research programs is available to meet the specific needs and interests of constituent groups. Communicating knowledge begins at the inception of a research project and increases in intensity as the effort reaches maturity. Included are the appropriate delivery, archiving, and future convenient access of all research results. Our goal is to share the information derived from research efforts with all in a useful, timely, and reliable manner.*



# Communicate Knowledge

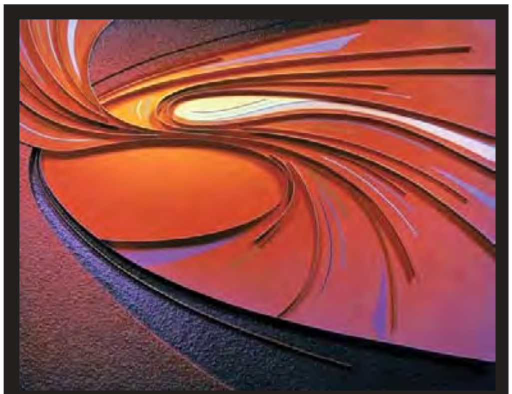
**Strategic Goal**

The Communicate Knowledge goal is to ensure that NASA's customers receive the information derived from the Agency's research and development efforts in a useful, timely, and reliable manner.

Achievements

The NASA Exhibits Program provides a vehicle to travel to local communities and target audiences at various ages and educational levels to share scientific and technological discoveries from NASA programs through captivating visuals and easily understandable terms. In FY 2001, the Exhibits Program exceeded its planned performance by providing over 1,933 exhibits and supporting over 675 events. For the Loaned Exhibit Program, this represents a 29-percent increase from FY 2000.

The Scientific and Technical Information Program provides timely scientific and technological data to meet the detailed needs of the scientific community and technical audiences. This program continues to make tremendous strides in providing customer service to the public as evidenced by receiving a 99-percent satisfaction rating from its 10,527 help desk customers. Also within the program, 16,133 citations of NASA reports or documents were added to the NASA Scientific and Technical Database, addressing the public's need for awareness about NASA's programs and exceeding its goal by nearly 22 percent. In FY 2000, the total number of NASA-sponsored, funded, and/or generated report documents for the scientific community and public was 17,379 new items, a 17-percent increase over this program's FY 1999 baseline of 10,550. This progress demonstrates that customers are getting the information derived from NASA research efforts.



**NASA combines science and engineering with art**

*Fluid Dynamics*, a mixed-media piece, by Tina York, depicts fluid dynamics studies at the Ames Research Center. The purpose of such studies is to learn more about what happens to an object when it encounters the friction of atmospheric resistance, such as a plane encountering resistance as it speeds through the air. It is a product of the NASA Art Program.

For more than 30 years, the NASA Art Program has documented America's major accomplishments in aeronautics and space. During that time, more than 200 artists have generously contributed their time and talent to record their impressions of the U.S. aerospace program in paintings, drawings, and other media. Not only do these artworks provide a historic record of NASA projects, they give the public a new and fuller understanding of advancements in aerospace.

NASA's art collection includes works by Robert McCall, Andy Warhol, Robert Rauschenberg, and Jamie Wyeth. The works depict a wide range of subjects, from Space Shuttle launches to aeronautics research, Hubble Space Telescope, and even virtual reality.

The NASA Art Program creatively interprets the human experience and inspiration that result from NASA endeavors. Articles in the *Wall Street Journal*, as well as stories aired by CNN and Fox News, have generated a lot of interest in NASA and its art initiatives. In 2001, public audiences were exposed to NASA endeavors through nontraditional vehicles, such as the Artrain USA, a traveling exhibit that transports NASA's art collection by train to cities across the United States.

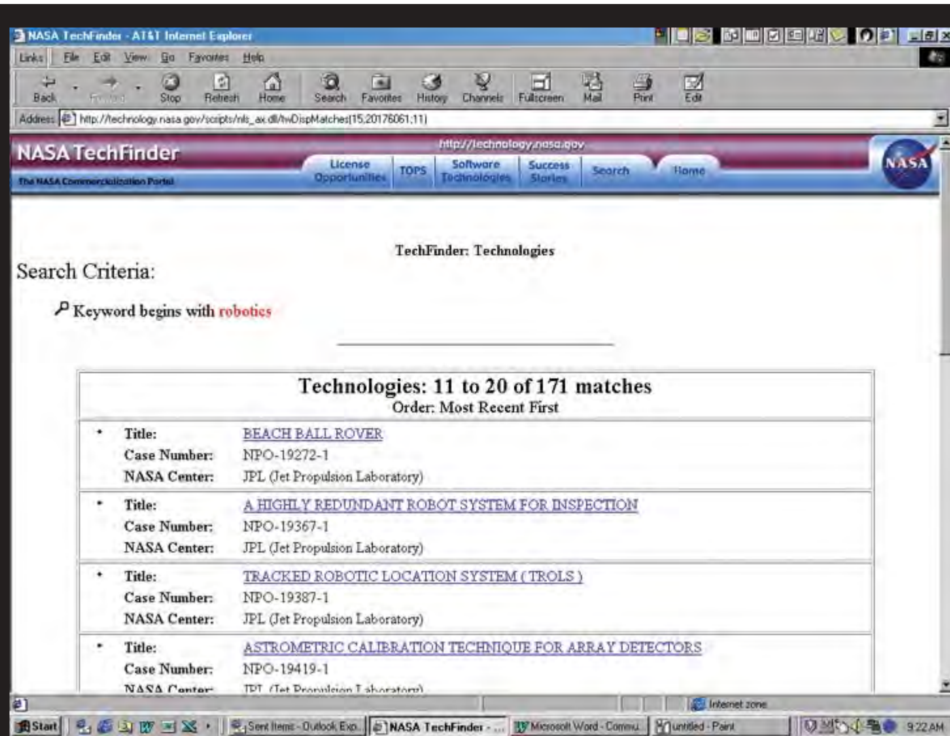
The Artrain exhibition presents 78 pieces of NASA art, documenting the Agency's history. The American public has watched NASA's history unfold through the eyes of American artists capturing such events as the Apollo 11 crew during suit-up or using a three-dimensional picture from Mars Pathfinder to create unique clothing. The first Artrain has traveled to Mississippi, Georgia, Louisiana, Texas, Kansas, Missouri, Iowa, Minnesota, North Dakota, Wisconsin, Illinois, and Indiana. The goal of Artrain is to reach over 40 states by the end of 2002. Beyond 2002, Artrain will travel throughout Canada for a year.

The Live Satellite Interview Program, designed to tell the NASA story in real time, produced 394 interviews during the second quarter of FY 2001. This program closed out the year by averaging 48 live satellite interviews per month, fully exceeding the target of 15. Live shots averaged 75 per month.

Interest in NASA programs is evident through the NASA home page web site where 72.5 million pages were downloaded in FY 2001. Although the number of pages was approximately 8 percent lower than in FY 2000 (79.1 million), this decline does not necessarily indicate a decreased interest in the NASA web site. During the same period, the number of site visits increased slightly in FY 2001 to 39.9 million, up from 37.7 million in FY 2000. The most likely explanation is that the stability of the web site's structure has allowed people to become very familiar with it. They are likely to bookmark the particular web pages in which they are interested, decreasing the number of pages they look through on each visit. Because of the uncertainty associated with interpreting this metric, in FY 2002 NASA will instead track the number of news stories posted on the NASA home page.

NASA Centers use the Internet to make the latest technological developments available to the public, as well as through educational programs. For example, the NASA *Tech Briefs* web site is available to download Technical Support Packages, which provide in-depth information on the innovations described in the NASA *Tech Briefs* publications. NASA also uses the online edition of *Aerospace Technology Innovation*, the public's source for current information on NASA projects and opportunities in the areas of technology transfer and commercialization, aerospace technology development, and the commercial development of space.

In FY 2001, 19,635 viable NASA technologies were made available to the public through the NASA Technology Tracking System or TechTracS database. The goal of 20,100 was not achieved this fiscal year, because NASA Centers remove technologies from the TechTracS database each year that are outdated or can no longer be supported with NASA expertise. In FY 2000, aiming to release 200 additional technologies over FY 2000 to the public through NASA TechTracS, the goal was exceeded by releasing 889 additional technologies. From year to year the number of removals will be greater or less than the new technologies that are added. Recognizing this challenge, the goal was changed in subsequent fiscal years to account for this continuous rebalancing to better measure NASA's commitment to provide technologies for the benefit of the public.




**NASA makes the latest technologies available to everyone**

By clicking the appropriate links in the NASA TechFinder, users can search the database for opportunities and submit requests for additional information. NASA TechFinder contains text and images from all NASA Centers. NASA TechFinder is updated within minutes of any changes made at a NASA Field Center. The screen capture shown above represents a small portion of the items listed in response to a search using the keyword "robotics."

To make people more aware and informed about NASA activities, we are making a concentrated effort to reach out to students of all ages and to publicize specific technical achievements. In cooperation with educational associations for mathematics and science technology, as well as geography and science centers, more and more educators are being introduced each year to the latest science and engineering at NASA. The teachers, representing all grade levels, are expected to share their newly acquired knowledge with their students. Each of the Agency's 10 Centers conducts educational programs, and the results from these demonstrate significant progress in our effort to communicate knowledge. The NASA Education Program exceeded planned performance by providing 3.6 million teachers, faculty, and students access to, and full participation in, NASA Education Programs, while receiving an excellent customer service rating of 4.62 for the year.

These activities highlight how NASA communicates knowledge through the distribution of information on NASA's missions and discoveries, and increase public understanding about science and technology.

## Challenges

NASA continues to face the difficult challenge of communicating complex scientific and technical content so it may be readily understood. The Agency is continually working to find new means to provide information to share the excitement of NASA science and engineering breakthroughs with the general public. Communication and sharing of scientific data, as well as the benefits and successes within our programs, are an inherent part of NASA's traditional business process. Attempting to measure the outcome of communicating NASA efforts is also a considerable challenge that the space program will continue striving to achieve.

## Assessments

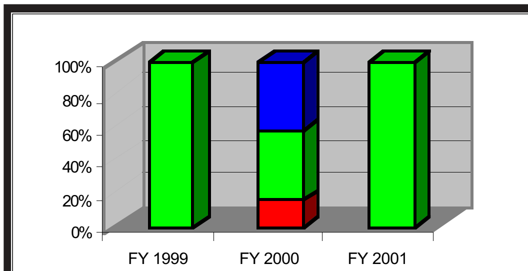
All four FY 2001 annual performance goals were achieved (green). We successfully achieved the goal to share the experience of expanding the frontiers of air and space with the public and other stakeholders as well as goals to share the results and benefits of our programs, ensuring consistent, high-quality, external communication, and using our ability to support meeting the Nation's education goals.

**Strategic Goal. Ensure that information derived from NASA's research efforts is distributed in a useful, timely, and reliable manner**

| APG | Description | Assessment |
|---|---|---|
| 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 annual performance goal. | ● (green) |
| 1CK2 | Inform, provide status, enthuse, and explain results, relevance and benefits of NASA's programs by meeting 2 of the 3 indicators. | ● (green) |
| 1CK3 | Ensure consistent, high-quality, external communication by meeting 2 of the 3 indicators for this annual performance goal. | ● (green) |
| 1CK4 | Use NASA's ability to support meeting the Nation's education goals by meeting 3 of the 4 indicators for this annual performance goal. | ● (green) |

## Trends

Annual performance goal achievement reached 100 percent (green) in FY 2001. This is an improvement over FY 2000, when 84 percent of the goals were either exceeded or achieved (blue and green). NASA also achieved 100 percent in FY 1999.




This chart shows that annual performance goal achievements in FY 2001 increased over FY 2000, and equaled FY 1999's 100-percent achievements.

## Awards, Honors, and Distinctions

NASA received numerous awards for outreach efforts. These awards include: the Infinity Award for Applied Photography to the Hubble Heritage Program for valuing "both scientific information and aesthetic presence" in producing celestial photographs; the International Technology Education Association's Presidential Citation to the New Millennium Program's Space Place Team "for efforts above and


**NASA wins through science communication**

4 April 2001. The Science@NASA family of six web sites, operated by NASA's Marshall Space Flight Center in Huntsville, Alabama, receives more than 330 million hits from Internet users a year. The cutting-edge style of science communication at Marshall is reflected in the content on the award-winning sites, which feature a broad range of science and space news. Ron Koczor, the NASA manager responsible for the sites, said, "It's heartening to know our science news is reaching not only people throughout the United States, but throughout the world as well.... We created a broad-scope roundtable process that ties together scientists, the web site production people, the writers and the NASA managers."

beyond the call of duty in service to the Technology Education profession"; and the 2000 Pirelli INTERNETional Award, which recognizes excellence in science communications and "the spread of science culture" using the Internet, for the Science@NASA family of Internet web sites.

## Partnerships

Many education and public outreach collaborations take advantage of the science content that is NASA's primary resource and leverage it through the expertise of organizations such as the Smithsonian Institution in developing and displaying exhibits.

# Provide Aerospace Products and Capabilities

*NASA provides aerospace products and capabilities, which means that all our facilities deliver systems (ground, aeronautic, space), technologies, data, and operational services to our customers. With the availability of Agency facilities, customers can conduct research, explore and develop space, and improve life on Earth. Working this way helps us answer the 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?" We can then deliver products and services to customers more effectively and efficiently. We can also enhance the communication of knowledge to extend the technology, research, and science benefits from NASA programs broadly to the public and commercial sectors.*

# Provide Aerospace Products and Capabilities

**Strategic Goal**

The Provide Aerospace Products and Capabilities process strategic goal is to enable NASA's Strategic Enterprises and their Centers to deliver products and services more effectively and efficiently while extending the technology, research, and science benefits broadly to the public and commercial sectors.

Achievements

In FY 2001, NASA reported substantial achievements in the areas of minimum downtime, software independent verification and validation, best practices and lessons-learned capture, commercial partnership development, and emerging technology investment. Although the Agency level goal for cost and schedule management was not met, NASA still obtained notable achievement in this area.

**When NASA builds it, it works**

16 August 2001. International Space Station flight controllers monitor data at their consoles in the station flight control room in Houston's Mission Control Center during the STS-105 mission. Keeping complex operations like these up and running is the result of outstanding engineering and management capabilities.

*Cost and Schedule*

Although NASA experienced challenges in some programs and projects in FY 2001, there were also substantial successes. Examples of well-managed missions include the Space Science Enterprise's Microwave Anisotropy Probe and Mars Surveyor launches and numerous Earth Observing System missions.

*Minimum Downtime*

NASA's world-class engineering capability is reflected by very low operational downtime of on-orbit spacecraft and supporting facilities. In FY 2001, an average of less than 1 percent (0.65) of scheduled operating time was lost to unscheduled downtime.

*Software Independent Verification and Validation*

The NASA Independent Verification and Validation Facility was established as part of an Agency-wide strategy to provide the highest achievable levels of safety and cost-effectiveness for mission critical software. In FY 2001, NASA marked the development of plans and policies, and the Facility's efforts contributed to NASA's improved safety record since the Facility's inception. One of the missions is to increase software safety and quality, reduce software costs, and improve delivery time through the early detection and resolution of errors, by utilizing and applying empirically based software engineering best practices. Since the evaluation of 93 NASA projects against Facility criteria in July 2000, 16 new projects have initiated either Independent Verification and Validation or Independent Assessment services with the Facility.

*Best Practices, Lessons Learned*

Numerous projects submitted lessons learned into the Lessons Learned Information System and some projects used other lessons learned systems at the various Centers.

## Challenges

NASA must improve in the areas of safety and mission assurance, program and project management, implementing the faster, better, cheaper approach to space exploration projects, research and technology demonstration/application, and partnerships. All these challenges are being addressed in the update of the relevant internal guidance document (referred to as the NASA Procedures and Guidelines 7120.5) and the implementation of corrective actions recommended by an internal review team formed after the Mars Climate Orbiter and Mars Polar Lander failures. By updating this document to reflect the corrective actions, NASA should strengthen the execution of its programs and projects and the utilization of resources.

### *Cost and Schedule*

The primary cost and schedule challenges in the Aerospace Technology Enterprise are in the area of experimental vehicles. In the case of the Hyper-X (X-43) project, the first of three planned flights was unsuccessful due to loss of controlled flight shortly after ignition of the booster to which the X-43 was mated. An investigation team has been gathering and analyzing the facts of the mishap to determine its cause(s) and recommend corrective actions to help achieve success on the second flight of the test program. Due to poor understanding of the X-37 flight test requirements, revisions to the project schedule and cost are needed. NASA and its U.S. Air Force and private-sector partners are currently evaluating other options for flight.

Several Earth Explorer missions, within the Earth Science Enterprise, experienced spacecraft and instrument technical challenges. In the Space Science Enterprise, the Space Infrared Telescope Facility Program encountered cost and schedule issues because of flight software and telescope assembly problems. The Relativity Mission/Gravity Probe-B had several technical challenges that affected cost and schedule. Also, the planned Outer Planets Program experienced continued cost increases and schedule issues for proposed missions, leading to their cancellation.

### *The Office of Space Flight*

In spite of its technical successes, the Space Station has not succeeded at staying within planned costs. Last year, NASA determined that it needed a 50-percent funding increase to its remaining $8.3 billion budget to finish the planned Space Station. The request marked just the latest chapter in a history of cost growth. To keep the Station within planned budgets, the Administration scaled it down to a core Station. The Space Station's Management and Cost Evaluation task force called on NASA to undertake management changes to achieve the core Station's goals.

NASA continues to invest in improving Shuttle safety, but some of the planned investments are experiencing significant problems. For example, the electric auxiliary power unit was the highest priority safety upgrade last year, but delays, technical difficulties, decreasing safety benefits and a tripling of its projected costs led NASA, with the support of its advisory committee, to cancel the project.

### *Best Practices, Lessons Learned*

Programs and projects benefit in many different ways from daily lessons learned. Some of these include status reporting, programmatic and technical reviews, and functional staff meetings. The more formal and widespread results include technical standards and updating NASA Procedures and Guidelines and other documentation. The various NASA training programs also incorporate lessons learned into their curricula, including storytelling by current and retired NASA program and project managers. One forum is designed specifically for sharing lessons learned and is titled, "Project Management Shared Experiences Program." The overall objective of this program is to provide a forum to understand key initiatives influencing NASA project management and for project people to share knowledge, experiences, and creative approaches to project management.

NASA must do a better job of documenting and communicating lessons learned, improving mechanisms by which the lessons learned sources are linked, and encouraging the proper training for employees in order to maximize the ability of current activities to draw upon the lessons of others.

Major revisions to 7120.5, NASA Program and Project Management Processes and Requirements, are in the final stages and include more clarity in the use and scope of the Lessons Learned Information System. Since NASA uses numerous sources for lessons learned, this information system will no longer be referred to as the primary source, but one of many.

## Assessments

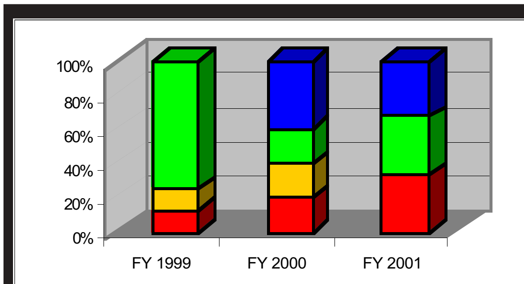
During FY 2001, we demonstrated successful performance in four of six annual performance goals, including very low operational downtime, developing a policy for software independent verification and validation, dedicating budget money to commercial partnerships, and completely redefining the NASA Technology Plan to emphasize investments in the emerging strategic cross-enterprise technology.

**Strategic Goal. Enable NASA's Strategic Enterprises and their centers to deliver products and services more effectively and efficiently while extending the technology, research, and science benefits broadly to the public and commercial sectors.**

| APG | Description | Assessment |
|---|---|---|
| 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. | Red |
| 1P3 | Ensure the availability of NASA's spacecraft and major ground facilities by keeping the operating time lost due to unscheduled downtime. | Blue |
| 1P4 | Capture a set of best practices/ lessons learned from each Program, to include at least one from each of the four Provide Aerospace Products and Capabilities (PAPAC) subprocesses documented in NASA Procedures and Guidelines (NPG) 7120.5, commensurate with current program status. Data will be implemented in PAPAC process improvement and in Program/ Project Management training. | Red |
| 1P5 | Dedicate 10 to 20 percent of the Agency's Research & Development budget to commercial partnerships. | Blue |
| 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. | Green |
| 1P7 | 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. | Green |

## Trends

FY 2001 annual performance achievement in enabling NASA to deliver products and services more effectively and efficiently was 67 percent (blue and green combined). This represents an increase from FY 2000, when 60 percent of the annual performance goals were achieved. There was a decrease from FY 1999, when achievement was 75 percent.




Annual performance goal achievement in enabling NASA's strategic enterprises to deliver products and services more effectively increased from FY 2000 to FY 2001.

## Partnerships

The percentage of NASA's research and development budget dedicated to commercial partnerships affects integrated technology planning and development with NASA partners. NASA contributed 17 percent of its research and development investment to commercial partnerships this year. The FY 2001 performance is significant, exceeding the National Performance Review goal for NASA, which is 10-20 percent of research and development base. This allows NASA the ability to produce more technology breakthroughs and science by leveraging financial and human capital. This is an overwhelming benefit to the public investment.


**NASA leverages resources through commercial partnerships**

*Aerospace Technology Innovation* is a bimonthly publication of the Commercial Technology Division at NASA Headquarters. It is one of many public sources for information on NASA projects and opportunities in the areas of technology transfer and commercialization, aerospace technology development, and the commercial development of space.

# Part III

## Detailed Supporting Material

# NASA's Strategic Enterprises

# Space Science

**Strategic Goal 1**

Chart the evolution of the universe from origins to destiny, and understand its galaxies, stars, and life.

**Annual Performance Goal 1S1**

Successfully develop and launch no fewer than three of four planned missions within 10% of budget and schedule. Missions are: Galaxy Evolution Explorer (GALEX), Microwave Anisotropy Probe (MAP), Gravity Probe B (GP-B), and Cooperative Astrophysics and Technology (CATSAT).

Indicators

- GALEX Development: Deliver the GALEX for launch; successful launch and checkout.
- MAP Development: Deliver the MAP for launch; successful launch and checkout.
- GP-B Development: Complete mating of GP-B payload and spacecraft.
- CATSAT Development: Deliver the CATSAT for launch; successful launch and checkout.
- Space Infrared Telescope Facility (SIRTF) Development: Spacecraft complete and ready for integration with Cryogenic Telescope Assembly (CTA). CTA complete and delivered to spacecraft contractor for integration with spacecraft.
- Stratospheric Observatory for Infrared Astronomy (SOFIA) Development: Install Protoflight 747 Cavity Door on Section 46 Cavity Mockup.
- Hubble Space Telescope (HST) Development: Install two key HST upgrades on Servicing Mission 3B: Advanced Camera for Surveys (ACS) and Solar Array 3 (SA3).
- Payload & Instrument Development - Planck: The Preliminary Breadboard Cooler Performance Report will be delivered.
- Explorer Program Future Missions: MIDEX 3&4: Throughout FY 2001, continue full-scale development of the Swift Gamma Ray Burst Explorer and the Full-sky Astrometric Mapping Explorer (FAME). Small Explorer Program (SMEX) 8&9: Down-selection planned.

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executives. Following the order of the indicators listed above, additional sources are:

- GALEX Development: October 2001, Governing Program Management Council Review at Goddard Space Flight Center
- MAP Development: June 29, 2001, Launch Readiness Review at KSC, July 2001 Monthly Flight Program Review at NASA Headquarters, Agency financial reporting systems
- GP-B Development: September 2001, Monthly Project Review at Stanford University
- CATSAT Development: May 7, 2001, Official Correspondence from NASA Administrator to University of New Hampshire
- SIRTF Development: August 2001, Program Quarterly Review at Jet Propulsion Laboratory

- SOFIA Development: May 2000, and October 2000, Project Reviews
- HST Development: October 2001, Program Management Council Review at NASA Headquarters
- Payload & Instrument Development-Planck: May 2001, Cryocooler Compressor Element Critical Design Review
- Explorer Program Future Missions: August 2001, Monthly Flight Program Review at NASA Headquarters.

Data Voids

None

Results

The annual performance goal was not achieved. The goal focused on indicators for four development missions that, at the time the Performance Plan was developed in 1999, were scheduled for launch in FY 2001; however, only one of the missions was successfuly launched. MAP is an Explorer mission that will measure the temperature of the cosmic background radiation over the full sky with unprecedented accuracy. This map of the remnant heat from the Big Bang will provide answers to fundamental questions about the origin and fate of our universe.

- GALEX Development: Not achieved. The GALEX project encountered problems in detector development and telescope fabrication. This, coupled with delays in electronics development due to loss of key manpower, resulted in a schedule slip. These issues have been resolved, and GALEX is currently scheduled for launch in May 2002.
- MAP Development: Achieved. MAP successfully launched from the Kennedy Space Center on June 30, 2001. MAP development was completed on time and under budget.
- GP-B Development: Not achieved. Due to a nitrogen contamination incident during shipment of the payload, there was a 1-month delay in mating the payload and spacecraft. GP-B critical milestone performance has been outstanding during FY 2000 and FY 2001. With the accomplishment of this milestone, GP-B is poised to enter its system level Integration & Test phase, and launch is scheduled for October 2002.
- CATSAT Development: No longer being pursued. CATSAT, selected for development at the University of New Hampshire as part of the Student Explorer Demonstration Initiative, was cancelled due to lack of progress and associated risk concerns. Equally important in this decision was the fact that the original scientific rationale for the mission had eroded; the scientific question of the origin of gamma-ray bursts has been largely solved, and two other approved missions will better examine the question in light of more recent knowledge.
- SIRTF Development: Not achieved. Completion of the SIRTF metric has been delayed until FY 2002 due to difficulties encountered with both the spacecraft and the Cryogenic Telescope Assembly (CTA). Spacecraft completion was delayed by flight software development problems and reaction control system contamination. The CTA completion was delayed due to technical anomalies during thermal vacuum testing. Each of these issues is being resolved, and completion of the metric is planned for FY 2002.

- SOFIA Development: Not achieved/no longer being pursued. The SOFIA milestone involving installation of a protoflight cavity door was eliminated as a result of several developments. First, evolution in the design and analysis of the cavity door progressed to a point at which eliminating this step did not pose significant risk. Second, other changes to the program plan eliminated the transport of the airplane to Germany for telescope integration, reducing the desirability of and opportunity for performing additional mockup activity. These two factors led to the removal of this step as part of an effort to alleviate program cost growth by eliminating all non-essential work.
- HST Development: Not achieved; however, delay was known prior to FY 2001, and progress during year was as planned. The HST continues to produce stunning images and groundbreaking science data. However, due to Space Shuttle manifest issues related to the International Space Station, Servicing Mission 3B is delayed until FY 2002.
- Payload & Instrument Development-Planck: Achieved. The Preliminary Breadboard Cooler Compressor Performance Report was completed and delivered.
- Explorer Program Future Missions: Partially achieved. Swift continues full-scale development. The FAME mission was not confirmed for development because of an increasing concern about cost growth. Due to budget constraints, the SMEX 8&9 down-select of two missions for flight is delayed until FY 2002. These budget shortfalls were caused by Pegasus-class launch vehicle failures, which are beyond NASA's control.

Assessment

**Yellow**

Action Plan

Action plans include:

- GALEX issues have been resolved, and GALEX is currently scheduled for launch in FY 2002.
- GP-B is poised to enter its system level Integration & Test phase.
- SIRTF issues are being resolved, and completion of the metric is planned for FY 2002.
- HST Servicing Mission 3B will be achieved with the successful launch of STS-109, scheduled for FY 2002.
- Explorer Program Future Missions: Due to the increasing concern about cost growth on the FAME mission, it was not confirmed for development. The SMEX 8&9 down-select of two missions for flight is now scheduled for FY 2002.

**Annual Performance Goal 1S2**

Obtain expected scientific data from at least 80% of operating missions. Missions are: Hubble Space Telescope (HST), Chandra X-ray Observatory (CXO), Rossi X-ray Timing Explorer (RXTE), Advanced Composition Explorer (ACE), Far Ultraviolet Spectroscopic Explorer (FUSE), Submillimeter Wave Astronomy Satellite (SWAS), and, if successfully launched, Galaxy Evolutionary Explorer (GALEX), and Gravity Probe B (GP-B).

**Indicators**

- HST Operations: Maintain an average on-target pointing efficiency of 35%, excluding the servicing mission and check-out and verification period.
- CXO Operations: Instruments meeting nominal performance expectations; complete 80% of pre-planned and commanded observations with 95% of science data recovered on ground.
- RXTE Operations: Successful operation of the Proportional Counter Array, the High Energy X-ray Timing Experiment, and the All-Sky Monitor (ASM) instruments, with an average of 3 PCUs (proportional counter units) operating at 45% efficiency or higher; 90% of data recovered; ASM data posted on the web within 7 days.
- ACE Operations: Measure the composition and energy spectra of heavy nuclei in six solar energetic particle events; measure the frequency and composition of coronal mass ejection events during the year; maintain real-time solar wind data 90% of the time.
- FUSE Operations: Measure interstellar gas velocities as small as 15 km per second, make 200 independent observations on line of sight in the Milky Way and nearby Galaxies; deliver 95% of the calibrated science observations to the FUSE archive on time.
- SWAS Operations: Dedicate 6,000 hours (on-source plus reference positions) to observations of galactic star forming regions, asymptotic giant branch stars, planetary nebulae, supernovae remnants, planets, and comets.

**Data Sources**

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data are provided by cognizant NASA Headquarters program executives and project scientists. Underlying data from Mission Operation Logs maintained at projects. Additional sources include:

- HST Operations: October 2001, Report to NASA Headquarters Program Executive
- CXO Operations: October 12, 2001, Report to NASA Headquarters Project Scientist
- RXTE Operations: October 11, 2001, Report to NASA Headquarters Project Scientist
- ACE Operations: October 10, 2001, Report to NASA Headquarters Project Scientist
- FUSE Operations: October 9, 2001, Report to NASA Headquarters Project Scientist
- SWAS Operations: October 15, 2001, Report to NASA Headquarters Project Scientist.

**Data Voids**

None

## Results

The annual performance goal was exceeded. All indicators were achieved, and the performance of SWAS, HST, CXO, and FUSE yielded important science results. The SWAS detected substantial concentrations of water vapor around the aging giant star CW Leonis, located 500 light-years (almost 3,000 trillion miles) from Earth. The observations provide the first evidence that other planetary systems contain water, a molecule that is an essential ingredient for known forms of life, and suggest that other stars may be surrounded by planetary systems similar to our own. These results led to a dedicated *Astrophysical Journal Letters* issue and a cover page feature of SWAS in the August 2001 issue of *Astronomy* magazine. The HST, in collaboration with the Keck telescope, observed the most distant galaxy ever seen. These observations will have profound implications for our understanding of how and when the first stars and galaxies formed in the universe. Many highly significant observations revealing the nature of black holes were obtained from the CXO in the past year, as evidenced by hundreds of articles in professional journals and popular magazines. In FY 2001 alone, the mission's results led to 34 press releases and over 250 newspaper stories. NASA's FUSE satellite provided the best view to date of the web of primordial gas which traces the mass concentrations in the early universe, which eventually form the stars and galaxies we know today. These observations of helium gas confirm theoretical models of how matter condensed into web-like structures pervading the space between galaxies.

- HST Operations: Achieved. Observational efficiency exceeded requirements for the entire reporting period, in spite of the Space Telescope Imaging Spectroscope's (STIS) failure of its primary side. Alternate observations were accomplished using the Wide Field/Planetary Camera 2 and Fine Guidance Sensors until recovery of the STIS.
- CXO Operations: Achieved. Performance goals were exceeded, with 99 percent of the pre-planned and commanded observations completed, and 100 percent data recovery.
- RXTE Operations: Achieved. The operational efficiency of an average of three PCUs was 67 percent during FY 2001, with data recovered exceeding 90 percent. ASM quick look data were posted on the web within 1 day collection time. Production data was posted within 7 days.
- ACE Operations: Achieved. ACE measured composition and energy of heavy nuclei in 15 solar particle events. Instruments measured composition on 22 coronal mass ejections, and produced solar wind measurements in real time better than 96 percent of the time.
- FUSE Operations: Achieved. Measurement precision was excellent, exceeding the 15 km per second threshold. FUSE made over 200 independent observations on lines of sight in the Milky Way and nearby galaxies. The delivery of calibrated science data to the science archive was performed within the 2-week requirement for more than 95 percent of the observations obtained in FY 2001.
- SWAS Operations: Achieved. SWAS dedicated approximately 7,900 hours (on-source plus reference positions) to observations of galactic star forming regions, asymptotic giant branch stars, planetary nebulae, supernovae remnants, planets, and comets.

Assessment

**Blue**

**Annual Performance Goal 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: Next Generation Space Telescope (NGST), Herschel Far Infrared and Submillimeter Telescope (FIRST), Gamma Ray Large Space Telescope (GLAST), Sounding Rockets, Balloons, and R&A. Achieve a “fully effective” (green) overall science achievement rating from the Space Science external advisory committee.

Indicators

- NGST Technology Development: Inflatable Shield in Space (ISIS) technology demonstration ready to fly on Shuttle; release Announcement of Opportunity (AO) for Science Instrument; down-select to a single phase 2 prime contractor.
- Herschel (FIRST) Technology Development: Complete the qualification mirror (QM) fabrication.
- GLAST Technology Development: Conduct successful Non-Advocate Review (NAR) for instrument development, project definition, and interface development.
- Sounding Rocket Flights: Achieve launch success rate of 80% for sounding rocket flights.
- Balloon Flights: Achieve launch success rate of 80% for balloon flights.
- Research and Analysis: Issue NASA Research Announcement (NRA) for Research Opportunities in Space Science (ROSS).

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data are provided by cognizant NASA Headquarters program executives. Program web sites and other sources include:

- NGST Technology Development: Web site hosting the NGST Request for Proposals (RFPs), http://ngst.gsfc.nasa.gov:80/project/procure
- Sounding Rocket Flights: Available at Sounding Rocket Project Results web page, http://www.wff.nasa.gov/pages/sr_results.html
- Balloon Flights: Available at Balloon Project Results web page, http://www.wff.nasa.gov/pages/bln_results.html
- R&A: Available at http://research.hq.nasa.gov/code_s/code_s.cfm
- Herschel FIRST Technology Development: August 2001, Flight Project Monthly Review at Headquarters
- GLAST Technology Development: August 2001, Quarterly Review at Stanford University
- Science Achievement data are recorded in the December 2001, Space Science Advisory Committee (SScAC) Report.

Data Voids

None

Results

The annual performance goal was achieved. In the Balloon Program, the High-Energy Replicated Optics (HERO) scientific balloon flight in May 2001 was the first flight mission of any type to use focusing hard X-ray optics. This important advance has the potential of allowing observations of objects 10 to 100 times fainter than those detected with other instruments, which will certainly lead to significant new discoveries. The Space Science external advisory committee rated science achievement in this area as having met (and in some areas exceeded) expectations, noting in particular the significant advances in NASA's understanding of black holes resulting from HST, CXO, and RXTE observations. For the NGST, the use of a desirable alternative technology and a delay in procurements caused the assigned metric to be missed. However, the decision to use an alternative technology produced cost savings, and the procurement delay allowed the project to achieve a maturer state of technology readiness prior to contractor selection, which is also likely to produce cost savings during the mission's development. The telescope activity for the European Space Agency (ESA) Herschel mission was terminated in FY 2000 and, as explained below, will not impact the success of the mission. The partial completion of the performance objectives for the technology program, combined with science achievement in the research program, led the external advisory committee to conclude that the overall assessment for this annual performance goal should be green.

- NGST Technology Development: Not achieved. The ISIS technology demonstration was cancelled in FY 2000, after the first Space Shuttle flight opportunity was moved 20 months to March 2002. The prime contractors competing for NGST have identified alternative technologies for a deployable sunshield, resulting in a significant cost savings. The draft of the AO was released in July 2001; however, the final release will occur in FY 2002. The delay was due to a number of factors, including foreign partner concurrence and the performance of an improved instrument cost estimate. Down-select to a single prime contractor is currently scheduled for FY 2002. The posting of the draft RFPs was delayed in order to resolve budget issues, and the release date for the final RFP was adjusted in order to allow appropriate time to respond to industry comments.
- Herschel FIRST Technology Development: Not Applicable; no longer being pursued. The U.S. Herschel telescope activity was cancelled prior to the beginning of the fiscal year due to increasing costs in meeting additional ESA requirements, as well as cost increases in other, higher priority, structure and evolution of the universe (SEU) programs. ESA requested the construction and delivery of an engineering model telescope, that would have increased NASA's costs by approximately $5 million. 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 the success of the program.
- GLAST Technology Development: Not achieved. The fourth quarter FY 2001 review concluded that the project was not yet ready to conduct a successful (NAR). The project is resolving the outstanding issues, and the NAR is currently scheduled for FY 2002.

- Sounding Rocket Flights: Exceeded. A launch success rate of 92% (11 of 12) was achieved for sounding rocket flights. Development continues on a new version of a meteorological rocket because of one unsuccessful test.
- Balloon Flights: Achieved. A launch success rate of 80% (12 of 15) was achieved for balloon flights. Development of the Ultra Long Duration Balloon is being revisited because of one unsuccessful test flight.
- Research and Analysis: Achieved. The NRA was released on January 26, 2001.
- Science Achievement Rating: Green

Assessment

**Green**

**Annual Performance Goal 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

- Mars Odyssey ('01 Orbiter) Development: Deliver for launch; successful launch and checkout.
- Genesis Development: Deliver for launch; successful launch and checkout.
- Rosetta Development: Deliver the flight units for the four U.S.-provided instruments or instrument subsystems to ESA.
- Two Wide-angle Imaging Neutral-atom Spectrometer (TWINS) Development: Continue instrument development and deliver Flight Unit #1 for Integration and Test.
- Comet Nucleus Tour (CONTOUR) Development: Successful Critical Design Review (CDR), meeting all program level requirements.
- Discovery Program Future Missions: New mission selection.

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executives. Program web sites and other source include:

- Discovery Program Future Missions: Available at http://research.hq.nasa.gov/code_s/code_s.cfm
- Mars Odyssey Development: April 2001, Flight Project Monthly Review available at NASA Headquarters, Agency financial reporting systems
- Genesis Development: August 2001, Flight Project Monthly Review available at NASA Headquarters, Agency financial reporting systems
- Rosetta Development: Project September 28, 2001, Weekly Report, posted on internal NASA web site
- TWINS Development: Project Report to NASA Headquarters Program Executive, October 15, 2001
- CONTOUR Development: CONTOUR Independent Assessment Team Report, January 11, 2001.

**Data Voids**

None

**Results**

The annual performance goal was achieved. The goal focused on indicators for two development missions that were scheduled for launch in FY 2001. Both of these indicators were achieved with the successful launches of the Mars Odyssey and Genesis missions. Mars Odyssey has arrived at Mars, where its instruments' observations will determine the elemental and chemical composition of the planet's surface. Genesis will collect samples of the charged particles in the solar wind and return them to Earth laboratories for detailed analysis after an airborne capture in the Utah desert. Such data are crucial for improving theories about the formation of the Sun and the planets, which formed from the same primordial dust cloud. The performance goal was supported further by achievement during FY 2001 of three of the four supporting indicators. The remaining indicator, for the TWINS mission, was achieved approximately 1 month into FY 2002, with no delay to the project's overall schedule.

- Mars Odyssey ('01 Orbiter) Development: Achieved. Mars Odyssey was successfully launched on April 7, 2001. Mars orbit insertion occurred on October 23, 2001, and operations are nominal. Odyssey development was completed on time and under budget.
- Genesis Development: Achieved. Genesis was launched on August 8, 2001, and successfully completed initial check-out, including the first trajectory correction maneuver per plan on August 10, 2001. Genesis development exceeded the established budget by 16 percent due to the addition of tasks in response to lessons learned from the 1999 Mars mission failures. The August 2001 launch exceeded the established January 2001 launch date by 18 percent.
- Rosetta Development: Achieved. All flight instruments were delivered to ESA.
- TWINS Development: Not achieved. Delivery of Flight Unit 1 was delayed approximately 1 month due to the failure of non-flight gratings during component level acoustic testing and changes to electronics boxes. This 1-month delay has not affected the overall mission schedule. The U.S. Air Force (spacecraft provider) is anticipating a 9-month mission launch delay, but the TWINS Project will deliver on time.
- CONTOUR Development: Achieved. Critical Design Review was successfully completed in December 2000.
- Discovery Program Future Missions: Achieved. Phase One selections were made in January 2001, with a full commitment to the NetLander mission. Phase Two selection is planned for FY 2002.

**Assessment**

**Green**

**Annual Performance Goal 1S5**

Obtain expected scientific data from at least 80% of operating missions. Missions are: Cassini, Voyager, Ulysses, Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), Fast Auroral Snapshot Explorer (FAST), Transition Region And Coronal Explorer (TRACE), Stardust, Mars Global Surveyor (MGS), and Integrated Space Transportation Plan (ISTP) spacecraft; also, if successfully launched, Thermosphere

Ionosphere Mesosphere Energetics and Dynamics (TIMED), High Energy Solar Spectrographic Imager (HESSI), Imager for Magnetopause-to-Aurora Global Exploration (IMAGE), Genesis, and Mars Odyssey ('01 Orbiter).

Indicators

- ISTP Operations: Continue to collect 85% of data acquired from the ISTP spacecraft and successfully execute the Wind trajectory plan.
- Cassini Operations: Complete development, test, and load Attitude and Articulation Control Subsystem flight software version A8.0; complete development, test, and load Command and Data Subsystem software version V9.0.
- Voyager Operations: Upload overlay command messages to Voyager 1 quarterly; record plasma wave data weekly (Voyager 1 and 2); return science data 10 hours per day.
- Ulysses Operations: Capture at least 90% of available Ulysses science data. These will be the only data observed from outside-of-the-ecliptic plane.
- SAMPEX Operations: Obtain at least 60% data coverage from at least three of SAMPEX's four instruments.
- FAST Operations: Simultaneously gather particle and fields data during 75% of its high altitude encounters with the northern hemisphere auroral zone and 25 percent of its high altitude encounters with the southern hemisphere auroral zone; successfully deliver at least 85% of these data.
- TRACE Operations: Conduct solar observing operations during all orbits where EUV images of the sun can be obtained using a 5-day-per-week/8-hour-per-day planning and operations cycle; deposit all TRACE data products into a web-based data system.
- Stardust Operations: Earth flyby for gravity assist.
- MGS Operations: Complete primary mapping mission.
- TIMED Operations: One complete season (at least 90 days) of successful data collection at the required resolution and accuracy.
- HESSI Operations: Obtain hard-X-ray images of solar flares with angular resolution approximately 2 arc seconds and energy resolution approximately 1 keV (kilo-electron volts); obtain high-resolution X-ray and gamma-ray spectra of solar flares with approximately 1 keV energy resolution to energies as high as 20 MeV (million electron volts).
- IMAGE Operations: Acquire measurements at minute time scales, returning 85% real-time coverage of the Earth's magnetospheric changes; perform routine pipeline processing of browse products and deliver to the National Space Science Data Center (NSSDC) within 72 hours.
- Genesis Operations: If launched, start operations, insert spacecraft into L-1 halo orbit and start science phase.
- Mars Odyssey ('01 Orbiter) Operations: Successfully perform required trajectory correction maneuvers and planned instrument checkout activities.

## Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters project scientists. Underlying data from Mission Operation Logs are maintained at projects. Program web sites and other sources included:

- TRACE Operations: October 2001, Report to NASA Headquarters Project Scientist; Project web site, http://vestige.lmsal.com/TRACE
- MGS Operations: February 2, 2001, Project Weekly Report, January 31, 2001, Jet Propulsion Laboratory Press Release (No. 2001-023MAH)
- ISTP Operations: October 2001, Report to NASA Headquarters Project Scientist
- Cassini Operations: September 2000, Monthly Flight Program Review at NASA Headquarters
- Voyager Operations: October 2001, Report to NASA Headquarters Project Scientist
- Ulysses Operations: October 2001, Report to NASA Headquarters Project Scientist
- SAMPEX Operations: October 2001, Report to NASA Headquarters Project Scientist
- FAST Operations: October 3, 2001, Report to NASA Headquarters Project Scientist
- TIMED Operations: Was not launched
- HESSI Operations: Was not launched
- IMAGE Operations: October 2001, Report to NASA Headquarters Project Scientist
- Genesis Operations: December 2000, Jet Propulsion Laboratory Monthly Project Review, August 2001
- Monthly Flight Program Review at NASA Headquarters
- Mars Odyssey Operations: Instrument status in June 29, 2002, Project Weekly Report; Trajectory Correction Maneuvers in May 25, 2001, July 6, 2001, and September 21, 2001, Project Weekly Reports.

## Data Voids

None

## Results

The annual performance goal was achieved. Ten of 12, or 83 percent, of the indicators were achieved. As noted below in regard to the two remaining indicators, the Cassini Project's FY 2001 progress has been good, and the Genesis spacecraft is operating nominally. Observations by the ISTP Solar Heliospheric Observatory (SOHO) mission yielded very significant science results. One involves the development of sunspots. Sunspots have fascinated scientists since Galileo's time, 400 years ago. Now the Michelson Doppler Imager (MDI) instrument enables humans to peer below the solar surface to observe the subsurface structure of sunspots and measure some of the properties of this structure that help explain how sunspots work. MDI is a U.S. investigation on the ESA-NASA SOHO mission.

- ISTP Operations: Exceeded. Data collection averaged greater than 99 percent. Wind successfully executed its trajectory plan.
- Cassini Operations: Not achieved; however, no concerns or issues exist. Completion of the Attitude and Articulation Control Subsystem (AACS) Version 8 and Command and Data Subsystem (CDS) Version 9 flight software development is now scheduled for FY 2002. Additional ground test time was incorporated to increase confidence in subsequent operations. Final on-board spacecraft flight software checkout will occur in FY 2003. This has no impact on current spacecraft cruise operations, and assures readiness for Saturn arrival in July 2004. However, more importantly, the Cassini Flight Operations Team was redeployed to solve problems with the ESA's Huygens Probe. With the assistance of the Jet Propulsion Laboratory, NASA averted a potential disaster for this $0.5 billion instrument.
- Voyager Operations: Achieved. Overlay command messages uploaded as planned. Plasma wave data recorded weekly or more frequently. Tracking for return of science data averaged 10.5 hours per day.
- Ulysses Operations: Achieved. Actual data capture rate was 99 percent.
- SAMPEX Operations: Achieved. Data coverage exceeded 95 percent.
- FAST Operations: Achieved. FAST gathered particle and fields data on greater than 90 percent of its high altitude encounters with both northern and southern hemisphere auroral zones. Data delivery exceeded 85 percent.
- TRACE Operations: Achieved. Solar observing operations conducted as planned; data products are available at http://vestige.lmsal.com/TRACE/Operations/DataSum/
- Stardust Operations: Achieved. Earth flyby for gravity assist was performed flawlessly in January 2001.
- MGS Operations: Achieved. Primary mapping mission completed February 1, 2001.
- TIMED Operations: Was not launched.
- HESSI Operations: Was not launched.
- IMAGE Operations: Achieved. IMAGE captured greater than 99 percent of the generated data. Processed data was placed on the web within an average of 48 hours.
- Genesis Operations: Not achieved. Operations were begun. However, due to the 6-month delay in launch, the orbit insertion and start of science phase will occur in FY 2002. This will have no impact on mission objectives. Sample return is now planned for September 2004.
- Mars Odyssey Operations: Achieved. Trajectory Correction Maneuvers 1, 2, and 3 were successfully conducted on May 23, 2001, July 2, 2001, and September 17, 2001, respectively. All instruments completed check-out as of June 30, 2001.

Assessment

**Green**

**Annual Performance Goal 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, X-2000, Sounding Rockets, and Balloons. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.

Indicators

- Solar-B Technology Development: Deliver engineering model of the optical telescope and X-ray telescope.
- STEREO Technology Development: Successfully complete Phase B effort, including Confirmation Review.
- Solar Probe Technology Development: Begin Solar Probe prototype thermal shield fabrication.
- Future Solar Terrestrial Probes Technology Development: Complete preliminary concept definitions for spacecraft systems and instruments for Magnetospheric Multiscale.
- Future Deep Space Technology Development: Deliver X-2000 Level 1-3 requirements documents; define subsystem interfaces; demonstrate intermediate-level multi-functional structures (MFS); complete definition of system architecture; evaluate key risk areas and pass decision gates.
- CISM Technology Development: Demonstrate and deliver prototype advanced power transistor (0.35 micron Siloconon Insulator [SOI] Complementary Metallic Oxide Semiconductor [CMOS] [sic]: demonstrate Active Pixel Sensor with advanced processing capabilities on a single chip.
- X-2000 Technology Development: Deliver engineering model and flight set of avionics.
- Sounding Rocket Flights: Achieve launch success rate of 80% for sounding rocket flights.
- Balloon Flights: Achieve launch success rate of 80% for balloon flights.

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data are provided by cognizant NASA Headquarters program executives. Program web sites and other sources include:

- Sounding Rocket Flights: Available at Sounding Rocket Project Results web page, http://www.wff.nasa.gov/pages/sr_results.html
- Balloon Flights: Available at Balloon Project Results web page, http://www.wff.nasa.gov/pages/bln_results.html
- Science Achievement: Data are available in the December 2001, Space Science Advisory Committee (SScAC) Report.

Data Voids

None

Results

The annual performance goal was achieved. The Solar Probe mission was deleted in the FY 2002 President's Budget. This mission, which may be pursued in future years, would make a close flyby of the Sun, providing data essential for understanding the source of the solar wind. Of the remaining indicators, five were achieved and progress on another (Solar-B) was good, although actual achievement of the indicator was delayed in response to the foreign partner's request. The Space Science external advisory committee rated science achievement in this area as having met (and in some areas exceeded) expectations. The committee noted in particular the significant advances in our understanding of asteroids and comets as the result of the Near-Earth Asteroid Rendezvous (NEAR) - Shoemaker spacecraft's landing on the asteroid Eros and the Deep Space 1 spacecraft's fly-by of Comet Borelly.

- Solar-B Technology Development: Partially achieved. As requested by the Japanese, delivery delayed until November 2001 due to a Japanese-initiated launch delay for the Solar-B mission.
- STEREO Technology Development: Not achieved. Launch dates of the TIMED and Solar-B missions were delayed due to requirements of NASA's foreign launch partners that were beyond NASA's control. The associated funding impacts were absorbed within the Solar Terrestrial Probes Program by delaying the STEREO launch date and associated major milestones. The confirmation review for STEREO is now scheduled for FY 2002.
- Solar Probe Technology Development: No longer being pursued. Funding for the Solar Probe mission was eliminated in the FY 2002 President's Budget. The close-out plan for suspending formulation of the project did not include initiating new work for fabrication of the prototype thermal shield.
- Future Solar Terrestrial Probes Technology Development: Achieved. All studies were completed in March 2001.
- Future Deep Space Technology Development: Achieved. Reformulation of the Outer Planets Program has now integrated the X-2000 technology activity into the Europa Orbiter development effort to gain efficiency. Level 1-3 requirements, documents and schedules were completed and integrated with the Europa Orbiter schedule. All Preliminary Design Reviews were completed and engineering model deliveries are beginning.
- CISM Technology Development: Achieved. CISM advanced avionics will enable more compact, low-power, and lightweight deep space orbiters, landers, and flyby spacecraft. The project demonstrated high voltage transistors with breakdown voltage of 18V on the Honeywell ultra rad hard SOI CMOS process. The performance of this transistor was characterized and initial results indicated that the transistor is highly reliable. Advanced Pixel Sensor (APS) chips were designed and fabricated both on bulk CMOS and SOI lines. The performance of the bulk CMOS design met the design expectation. Next generation bulk CMOS APS chips were fabricated in September 2001. The performance of the SOI version of the design was successfully demonstrated at the Massachusetts Institute of Technology Lincoln Laboratories.

- X-2000 Technology Development: Not achieved. Reformulation of the Outer Planets Program has now integrated the X-2000 technology activity into the Europa Orbiter development effort to gain efficiency. The anticipated delivery schedule for the engineering model avionics is now FY 2002, in accordance with the reformulated Europa Orbiter Project schedule. The delivery of the flight avionics is currently scheduled for FY 2004. (Note: This is one of two FY 2001 metrics for X-2000. The other metric was completed as planned, and noted above.)
- Sounding Rocket Flights: Achieved. A launch success rate of 92 percent (11 of 12) was achieved for sounding rocket flights. Development continues on a new version of a metorological rocket because of one unsuccessful test flight.
- Balloon Flights: Achieved. A launch success rate of 80 percent (12 of 15) was achieved for balloon flights. Development of the Ultra-Long Duration Balloon is being revisited because of one unsuccessful test flight.
- Science Achievement Rating: Green

Assessment

**Green**

**Annual Performance Goal 1S7**

Perform innovative scientific research and technology development by meeting interferometry technology development objectives and by making satisfactory research progress in related Research and Analysis (R&A) programs. Meet no fewer than 66% of the performance objectives for Space Interferometry Mission (SIM), Terrestrial Planet Finder (TPF), StarLight (ST-3), Keck, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.

Indicators

- SIM Technology Development: Complete System Requirements Review (SRR), initiate Phase B, and demonstrate stabilization for nulling to one nanometer.
- TPF Technology Development: Award architectural definition contracts, develop RFP for second phase of industrial contracts, and test starlight nulling breadboard.
- ST-3 Technology Development: Successfully complete Preliminary Design Review (PDR); successfully complete project and spacecraft CDR.
- Keck Interferometer Technology Development: Combine 2 Keck telescopes for interferometry.
- Research and Analysis: Issue NASA Research Announcemenet (NRA) for Research Opportunities in Space Science (ROSS).

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant Headquarters program executives. Program websites and other sources include:

- Research and Analysis: The announcement is publicly available at http://research.hq.nasa.gov/code_s/code_s.cfm
- Science Achievement data are recorded in the December 2001, Space Science Advisory Committee (SScAC) Report.

**Data Voids**

None

**Results**

The annual performance goal was achieved. Progress was good and indicators were met for the TPF, the Keck Interferometer, and the Research and Analysis Program. The Space Science external advisory committee rated science achievement in this area as having exceeded expectations, noting the significant advances of the Hubble Space Telescope and Keck in identifying new planetary systems and studying their physical characteristics. The Keck Project successfully linked the world's two largest telescopes to create a single optical instrument powerful enough to pinpoint planets orbiting other stars. Delays were encountered for the Space Interferometry Mission, and a previously adjusted schedule for the StarLight mission did not call for achievement of its indicator during FY 2001. The new design concept for SIM, which will detect planets around other stars and precisely locate very dim stars to an unprecedented accuracy, delays launch of the mission, but does not diminish its science value. The partial completion of the performance objectives for the technology program, combined with science achievement in the research program, led the external advisory committee to conclude that the overall assessment for this annual performance goal should be green.

- SIM Technology Development: Not achieved. In October 2000, in response to cost growth, the Project was directed to develop alternative architectural concepts that would meet science and budget requirements. In May 2001, SIM was approved to proceed with a new design concept that met these requirements. The revised schedule for the re-baselined mission delays the System Requirements Review to FY 2002.
- TPF Technology Development: Achieved. Phase One architectural definition contracts were awarded in April 2000, with options for Phase Two. These options eliminated the need for a second RFP. Phase One concluded with the Preliminary Architecture Review held in December 2000. In January 2001, Phase Two awards were made to four teams for further architecture definition and technology planning. In February 2001, the infrared nulling breadboard was successfully operated for the first time at the Jet Propulsion Laboratory.
- ST-3 Technology Development: Not achieved. Progress in FY 2001 was good; however, previous significant program rephasing and replanning to bring the ST-3 and the TPF missions into alignment resulted in an extended concept development phase for the ST-3 mission. The mission will demonstrate the ability to fly multiple spacecraft in formation; the design for the future TPF mission relies on this technology. The Preliminary Design Review is now scheduled for FY 2003, and the Critical Design Review for FY 2004.
- Keck Interferometer Technology Development: Achieved. The two Keck telescopes were successfully combined. First results using full apertures of both Keck Telescopes, adaptive optics, and beam combining hardware and software occurred on March 12, 2001.
- Research and Analysis: Achieved. NASA Research Announcement for ROSS was released on January 26, 2001. Approximately 1,500 grants were awarded following

the rigorous peer-review process that examines and evaluates each proposal submitted in response to the Announcement.

- Science Achievement Rating: Green

Assessment

**Green**

**Annual Performance Goal 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 TPF.

Indicators

- Mars Odyssey ('01 Orbiter) Development: Deliver for launch, within 10% of planned development budget and schedule; successful launch and checkout.
- Mars Global Surveyor Operations: Complete primary mapping mission.
- TPF Technology Development: Award architectural definition contracts, develop Request for Proposals (RFP) for second phase of industrial contracts, and test starlight nulling breadboard.

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executives and project scientists. Additional sources include:

- Mars Odyssey Development: April 2001, Flight Project Monthly Review at NASA Headquarters, Agency financial reporting systems
- Mars Global Surveyor (MGS) Operations: February 2, 2001, Project Weekly Report, January 31, 2001, Jet Propulsion Laboratory Press Release (#2001-023MAH)
- Terrestial Planet Finder (TPF) Technology Development: May 17, 2001, Terrestrial Planet Finder State of the Theme Report, February 7, 2001, and May 9, 2001, Monthly Governing Program Management Council (GPMC) Reviews at the Jet Propulsion Laboratory.

Data Voids

None

Results

The annual performance goal was exceeded. The Mars Global Surveyor (MGS) completed its primary mapping mission and continued its unprecedented success in its extended mission during FY 2001. MGS mapped landing sites for the 2003 Mars Exploration Rover mission, monitored the largest planet-encircling dust storm since 1971, and discovered potential evidence of present-day climate change. The Mars Odyssey spacecraft was also successfully launched in FY 2001. It has since arrived at Mars and has begun a new phase of unprecedented scientific reconnaissance. High-resolution orbital imaging will follow up on MGS results that suggest the presence of near-surface water in recent times. The Terrestrial Planet Finder (TPF) mission continued procurement activities, and successfully tested the starlight nulling breadboard. TPF will be able to search about 200 nearby stars for planets that possess atmospheres that would indicate the possible presence of life.

- Mars Odyssey Development: Achieved. Mars Odyssey was successfully launched on April 7, 2001. Mars orbit insertion occurred on October 23, 2001, and operations are nominal.
- MGS Operations: Achieved. Primary mapping mission was completed on February 1, 2001.
- TPF Technology Development: Achieved. Phase One architectural definition contracts were awarded in April 2000, with options for Phase Two. These options eliminated the need for a second Request for Proposal. Phase One concluded with the Preliminary Architecture Review held in December 2000. In January 2001, Phase Two awards were made to four teams for further architecture definition and technology planning. In February 2001, the infrared nulling breadboard was successfully operated for the first time at the Jet Propulsion Laboratory.
- Science Achievement Rating: Blue

Assessment

**Blue**

**Annual Performance Goal 1S8**

Perform innovative scientific research and technology development by meeting technology development objectives and by making satisfactory research progress in the related Research and Analysis (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.

Indicators

- Europa Orbiter Technology Development: Complete Preliminary Design Review.
- Astrobiology Research: 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.
- Research and Analysis: Issue NASA Research Announcement (NRA) for Research Opportunities in Space Science (ROSS).

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executives and project scientists. Program web sites and other sources include:

- NAI Second General Members' Meeting Abstract Volume available at http://nai.arc.nasa.gov, will be published by the journal *Astrobiology*; Report on Research Proposals of New Teams Selected in 2001 (in print)
- NASA Astrobiology Institute (NAI) Report to the National Research Council's Solar System Exploration Decadal Strategy Working Group: http://argyre.colorado.edu/life/NAI-report-to-NRC.html

- Research and Analysis: The Announcement is publicly available at http://research.hq.nasa.gov/code_s/code_s.cfm
- Executive Council "Report on the NAI" (draft available)
- Astrobiology Research: Annual Report, covers Year 2 (7/00-7/01) of the NASA Astrobiology Institute (NAI) (Year 3 Report in development)
- Science Achievement data are recorded in the December 2001, Space Science Advisory Committee (SScAC) Report.

Data Voids

None

Results

The annual performance goal was achieved. Two of the three indicators were met, and progress in the third area, the Europa Orbiter Project, was good. The Space Science external advisory committee rated science achievement in this area as having met expectations. The NASA Astrobiology Institute (NAI) exceeded its goals for the year, and was quite successful in sharing the results of its work beyond the traditional science community. NAI's education and public outreach efforts included three teacher workshops, and the production of classroom materials (*Astrobiology in Your Classroom* [K-12] and *Voyages Through Time* [9-12]), webcasts (*Mysteries of Microbes,* http://quest.nasa.gov/projects/astrobiology/fieldwork/index.html), and internet resources (*Microscope*, http://www.mbl.edu/microscope, *AstroVenture*, http://astroventure.arc.nasa.gov, *Ask an Astrobiologist* and *Astrobiology Pathfinder*, both at http://nai.arc.nasa.gov). The Institute also held multiple public lectures and produced general interest publications such as *Astrobiology: The Search for Life in the Universe*. The Europa Orbiter will orbit Jupiter's icy moon to determine if there is an underlying ocean. As a possible liquid water habitat in our Solar System, Europa is a critical target in the search for life beyond Earth. Research conducted under awards from the ROSS NRA further supports this goal by providing for the analysis and interpretation of results from current and past missions.

- Europa Orbiter Technology Development: Not achieved; however, delay was known prior to FY 2001, and progress during year was as planned. The Preliminary Design Review is to be rescheduled due to significant reductions in the FY 2002 budget and concerns regarding spacecraft mass, power, and avionics subsystems. Launch vehicle qualification for launch of a spacecraft with a radioisotope power system is also a concern. The project is focusing on X-2000 development as budget and trajectory issues are worked in parallel. It is anticipated that PDR will occur after FY 2002.
- Astrobiology Research: Achieved. The NASA Astrobiology Institute supports 15 research consortia, termed "Lead Teams," distributed among 11 academic and research institutions and 3 NASA centers. Four of these Lead Teams were selected and initiated in FY 2001 specifically to address the remaining areas identified for high-priority studies. Institute-wide functions are supported by piloting, testing, evaluation, and distribution of collaborative technologies, such as extensive use of video conferencing. The Institute's work has resulted in over 750 publications (peer-reviewed papers, abstracts, books, etc.), a substantial proportion of which are interdisciplinary in nature. NAI is a long-term commitment between NASA and the science community, anticipated to span decades.

- Research and Analysis: Achieved. The Research Announcement for Research Opportunities in Space Science (ROSS) was released on January 26, 2001. Approximately 1,500 grants will have been awarded following the rigorous peer-review process that examines and evaluates each proposal submitted in response to the Announcement.
- Science Achievement Rating: Green

Assessment

**Green**

## Strategic Goal 2

Contribute measurably to achieving the science, math, and technology education goals of our nation.

### Annual Performance Goal 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.

Indicators

Education and Public Outreach: Successful achievement of at least six of the following eight objectives will be made:

- Every mission initiated in FY 2001 will have a funded education and outreach program with a comprehensive education and outreach plan prepared by its Preliminary Design Review (PDR).
- By the end of FY01, 10 percent of all research grants will have a funded education and outreach program underway.
- Enterprise-funded education and outreach activities will be in planning or implementation in at least 34 states.
- At least five Enterprise-funded research, mission development or operations, or education projects will be underway in Historically Black Colleges and Universities (HBCU), Hispanic Serving Institutions (HSI), and Tribal Colleges (TCU), with at least one being underway in an institution of each type.
- The Enterprise will provide exhibits, materials, workshops, and personnel at a minimum of five national and three regional education and outreach conferences.
- At least five major Enterprise-sponsored exhibits or planetarium shows will be on display or on tour at major science museums or planetariums across the country.
- The first comprehensive Space Science Enterprise Education/Outreach Report will be prepared that describes participants, audiences, and products for Enterprise education and outreach programs.
- Initial results of a pilot assessment of the Enterprise's approach to education and outreach will be available for determining whether adjustments in program direction or organization are needed.

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.html.

Performance data provided by the Education and Public Outreach (E/PO) Director, based on direct reports from participants and compilation of information obtained through the Space Science Enterprise E/PO tracking and reporting system.

All FY 2001 data is available for public review in the Space Science Enterprise FY 2001 E/PO Annual Report at http://ossim.hq.nasa.gov/ossepo/2001/index.html. The data is certified by the Space Science Enterprise E/PO Director, and it is complemented by an external evaluation of program achievements led by the Program Evaluation and Research Group at Lesley University. In addition, a task force of the Space Science Advisory Committee will conduct a comprehensive review of the Space Science Enterprise E/PO program during FY 2002 and FY 2003.

Data Voids

None

Results

The annual performance goal was achieved. The role of education and enhanced public understanding of science in Space Science Enterprise research and flight programs has substantially expanded during FY 2001. Six of the eight performance indicators were achieved or greatly exceeded; two were not met (or not verified due to insufficient staffing).

- In FY 2001, four new space science flight missions were initiated. All of these missions have funded E/PO programs and some have comprehensive plans for carrying out those programs.
- By the end of FY 2001, approximately 2 percent of all grants for small research projects had a funded E/PO program underway. This is an improvement over the approximately 1 percent of such grants that had E/PO projects underway in FY 2000.
- Over 400 Enterprise-funded education and outreach activities took place in all 50 states during FY 2001, greatly exceeding the metric of planning or implementing such activities in at least 34 states. These events included shows, exhibits, and displays at hundreds of planetariums and science museums; displays and workshops at national and regional education and outreach conferences; support of classroom education through systemic initiatives, teacher enhancement programs, and direct interactions with students; and a wide variety of events that reached the public in settings ranging from local shopping malls to national television and web broadcasts.
- In FY 2001, 15 minority universities began work on Enterprise-funded space science development activities under the Space Science Minority University Initiative. Included among these 15 institutions were 6 Historically Black Colleges and Universities (HBCU), 3 Hispanic Serving Institutions (HSI), and 3 Tribal Colleges (TCU).
- NASA Space Science provided exhibits, materials, workshops, and personnel to more than 20 national and 40 regional education and outreach conferences during FY 2001. This greatly exceeds the FY 2001 metric of having such a presence at five national and three regional conferences.
- The following five major, Enterprise-sponsored space science exhibits or planetarium shows were on display or on national tours at major science museums or planetariums across the country in FY 2001:

—Explore the Universe (Washington, DC)

—Hubble Space Telescope: New Views of the Universe—Large Version (Houston, Texas; Ashland, Nebraska; Raleigh, North Carolina)

—Hubble Space Telescope: New Views of the Universe—Small Version (Saginaw, Michigan; Springfield, Massachusetts; Bettendorf, Iowa; Oakland, California)

—MarsQuest (Birmingham, Alabama; Orlando, Florida; Tucson, Arizona), and

—Space Weather (Baltimore, Maryland; Greenbelt, Maryland).

- The first comprehensive Space Science Enterprise Education and Public Outreach (E/PO) Annual Report was completed in January 2001, published in March 2001, and made available in a searchable version on-line at http://spacescience.nasa.gov/education/.
- Preliminary data collected for FY 2001 indicate that Office of Space Science (OSS) E/PO projects received over 40 awards from external organizations during the year, including over 20 awards for excellence in educational web sites. The most prestigious of these awards included such honors as:

—The Infinity Award for Applied Photography to the Hubble Space Telescope Heritage program for valuing "both scientific information and aesthetic presence" in producing celestial photographs;

—The International Technology Education Association's Presidential Citation to the New Millennium Program's Space Place Team "for efforts above and beyond the call of duty in service to the Technology Education profession"; and

—The National Science Teachers' Association SciLinks Web Awards to the Space Place and the Passport to Knowledge web sites.

Assessment

**Green**

## Strategic Goal 3

Support human exploration through robotic missions.

### Annual Performance Goal 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 Research and Analysis (R&A) and Data Analysis (DA) programs. Meet no fewer than 75% of the performance objectives for Mars Odyssey ('01 Orbiter), Comet Nucleus Tour (CONTOUR), Mars Global Surveyor, and R&A. Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.

Indicators

- Mars Odyssey ('01 Orbiter): Deliver for launch, within 10% of planned development budget and schedule; successful launch and check-out.
- CONTOUR Development: Successful Critical Design Review (CDR), to document that the design meets all program level requirements.
- Mars Global Surveyor Operations: Complete primary mapping mission.
- Research and Analysis: Issue NASA Research Announcement (NRA) for Research Opportunities in Space Science (ROSS).

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executives and project scientists. Program web sites and other sources include:

- Research and Analysis: The announcement is publicly available at http://research.hq.nasa.gov/code_s/code_s.cfm
- Mars Odyssey Development: April 2001, Flight Project Monthly Review at NASA Headquarters Agency financial reporting systems
- CONTOUR Development: CONTOUR Independent Assessment Team Report, January 11, 2001
- MGS Operations: February 2, 2001, Project Weekly Report, January 31, 2001 Jet Propulsion Laboratory Press Release (#2001-023MAH)
- Science Achievement data are recorded in the December 2001, Space Science Advisory Committee (SScAC) Report.

Data Voids

None

Results

The annual performance goal was exceeded. All four indicators were met, and Mars Global Surveyor (MGS) results significantly exceeded expectations. MGS completed its primary mapping mission and continued its unprecedented success in its extended mission during FY 2001. MGS mapped landing sites for the 2003 Mars Exploration Rover mission, monitored the largest planet-encircling dust storm since 1971, and discovered potential evidence of present-day climate change. A major collection of research articles based on MGS results was published in the *Journal of Geophysical Research (Planets)*. As a result of the accomplishments of MGS, the Space Science external advisory committee rated science achievement in this area as having exceeded expectations. In addition, the Mars Odyssey mission was successfully launched in FY 2001. It has since arrived at Mars and has begun a new phase of unprecedented scientific reconnaissance. Odyssey will be followed by the 2003 Mars Exploration Rover and 2005 Mars Reconnaissance Orbiter missions, which continued development during the year. The CONTOUR mission, which will improve our understanding of the key characteristics and diversity of comets, successfully completed a key milestone during FY 2001, and development proceeds toward a 2002 launch. Research conducted under awards from the ROSS NRA further supports this goal by providing for the analysis and interpretation of results from current and past missions.

- Mars Odyssey Development: Achieved. Mars Odyssey was successfully launched on April 7, 2001. Mars orbit insertion occurred on October 23, 2001, and operations are nominal.
- Comet Nucleus Tour: Achieved. Critical Design Review was successfully completed in December 2000.
- Mars Global Surveyor Operations: Achieved. Primary mapping mission completed February 1, 2001.
- Research and Analysis: Achieved. The Research Announcement for Research Opportunities in Space Science (ROSS) was released on January 26, 2001. Approximately

1,500 grants will have been awarded following the rigorous peer-review process that examines and evaluates each proposal submitted in response to the Announcement.

- Science Achievement Rating: Blue

Assessment

**Blue**

**Annual Performance Goal 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 Research and Analysis (R&A) and Data Analysis (DA) programs. Meet no fewer than 75% of the performance objectives for Research and Analysis, Advanced Composition Explorer (ACE), SAMPEX, Transition Region and Coronal Explorer (TRACE), International Solar-Terrestrial Physics Program (ISTP), and, if successfully launched, High Energy Solar Spectrographic Imager (HESSI). Achieve a "fully effective" (green) overall science achievement rating from the Space Science external advisory committee.

Indicators

- ISTP Operations: Continue to collect 85% of data acquired from the ISTP spacecraft and successfully execute the Wind trajectory plan.
- ACE Operations: Measure the composition and energy spectra of heavy nuclei in six solar energetic particle events; measure the frequency and composition of coronal mass ejection events during the year; maintain real-time solar wind data 90% of the time.
- SAMPEX Operations: Obtain at least 60% data coverage from at least three of SAMPEX's four instruments.
- TRACE Operations: Conduct solar observing operations during all orbits where Extreme Ultraviolet (EUV) Spectrometer images of the sun can be obtained using a 5-day-per-week/8-hour-per-day planning and operations cycle; deposit all TRACE data products into a web-based data system.
- HESSI Operations: Obtain hard-X-ray images of solar flares with angular resolution approximately 2 arcseconds and energy resolution approximately 1 keV (kilo-electron volts); obtain high-resolution X-ray and gamma-ray spectra of solar flares with approximately 1 keV energy resolution to energies as high as 20 MeV (million electron volts).
- Research and Analysis: Issue NASA Research Announcement (NRA) for Research Opportunities in Space Science (ROSS).

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executive. Program web sites and other sources include:

- TRACE Operations: October 2001 Report to NASA Headquarters project scientist; project web site, http://vestige.lmsal.com/TRACE
- Research and Analysis: Announcement, NASA Headquarters web site available at http://research.hq.nasa.gov/code_s/code_s.cfm.

- Daily far side images of the Sun can be seen at http://sun.stanford.edu/~phil/farside/back/gifs/recent.html
- HESSI Operations: Was not launched
- ISTP Operations: October 2001, Report to NASA Headquarters Project Scientist
- ACE Operations: October 10, 2001, Report to NASA Headquarters Project Scientist
- SAMPEX Operations: October 2001, Report to NASA Headquarters Project Scientist
- Science Achievement data are recorded in the December 2001, Space Science Advisory Committee (SScAC) Report.

Data Voids

None

Results

The annual performance goal was achieved. All five indicators were met, and observations by the International Solar-Terrestrial Physics Program (ISTP) Solar Heliospheric Observatory (SOHO) mission yielded critical science results. The Michelson Doppler Imager (MDI) SOHO instrument discovered how to see through the Sun and now, on a daily basis, uses this technique to study sources of activity on the far side. This is an important breakthrough because it provides warnings of the growth of potentially hazardous active regions fully a week before they come into view. MDI is a U.S. investigation on the European Space Agency (ESA)-NASA SOHO mission. The Space Science external advisory committee rated science achievement in this area as having met expectations.

Research conducted under awards from the ROSS NRA further supports this goal by providing for the analysis and interpretation of results from current and past missions.

- ISTP Operations: Exceeded. Data collection averaged greater than 99 percent. Wind successfully executed its trajectory plan.
- ACE Operations: Achieved. ACE measured composition and energy of heavy nuclei in 15 solar particle events. Instruments measured composition on 22 coronal mass ejections, and produced solar wind measurements in real time better than 96 percent of the time.
- SAMPEX Operations: Achieved. Data coverage exceeded 95 percent.
- TRACE Operations: Achieved. Solar observing operations conducted as planned; data products are available at http://vestige.lmsal.com/TRACE/Operations/DataSum/
- HESSI Operations: Was not launched.
- Research and Analysis: Achieved. The Research Announcement for Research Opportunities in Space Science (ROSS) was released on January 26, 2001. Approximately 1,500 grants were awarded following the rigorous peer-review process that examines and evaluates each proposal submitted in response to the Announcement.
- Science Achievement Rating: Green

**Assessment**

**Green**

**Annual Performance Goal 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 the following Living With a Star program elements: 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.

**Indicators**

- Strategic Plan: Complete Living With a Star Strategic Plan, including mission architecture, for the OSS Strategic Plan.
- Solar Dynamics Observatory: Complete definition study for the Observatory, the first major new flight mission for Living With a Star.
- Research & Data Analysis: Initiate targeted data analysis and modeling research grants program.

**Data Sources**

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executive. Program web sites and other sources include:

- Strategic Plan: Available at http://lws.gsfc.nasa.gov/objectives.htm
- Solar Dynamics Observatory: Science Definition Team Report, available at http://lws.gsfc.nasa.gov/sdo.htm
- Research and Data Analysis: Announcement of awards documented at http://research.hq.nasa.gov/code_s/nra/current/NRA-00-OSS-01/LWSabstracts.html
- Science Achievement data are recorded in the December 2001, Space Science Advisory Committe (SScAC) Report.

**Data Voids**

None

**Results**

The annual performance goal was achieved. All three indicators were met. The Living With a Star Program is a NASA initiative to improve our understanding of space weather and the effects of the Sun on Earth. Solar variability can affect space systems, human space flight, electric power grids, Global Positioning System (GPS) signals, high frequency radio communications, long-range radar, microelectronics and humans in high altitude aircraft, and the Earth's climate. The work completed under this initiative during FY 2001 lays the groundwork for achieving a better understanding of these effects. The Space Science external advisory committee rated science achievement in this area as having met expectations.

- Strategic Plan: Achieved. In response to a requirement in Conference Report 106-988, accompanying House Resolution (H.R.) 4635, the FY 2001 VA-HUD Independent Agencies Appropriations Act, the Living With a Star Strategic Plan was completed early, in August 2000. The Conference Report required submission of the plan by February 2001.

- Solar Dynamics Observatory: The SDO Science Definition Team completed the study and documented findings in their report in July 2001.
- Research and Data Analysis: The Living With a Star data analysis and modeling research grants program was initiated under the Research Opportunities in Space Science (ROSS) NASA Research Announcement (NRA) released during FY 2000. Awards for proposals in response to the Announcement were in place during FY 2001.
- Science Achievement Rating: Green

Assessment

**Green**

**Strategic Goal 4**

Develop new technologies needed to carry out innovative and less costly mission and research concepts.

**Annual Performance Goal 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.

Indicators

- Information Systems: Demonstrate Virtual Observatory capability from investigator workstation for multi-wavelength discovery, analysis, and visualization across collective set of space and ground astronomical surveys; demonstrate a Virtual Mars capability simulating rovers navigating Mars terrain, for planning and design of future Mars missions.
- High Performance Computing: 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).
- Explorer Program Technology: Complete 45 Explorers Technology Investigations selected in FY99. Implement awards for additional investigations planned for selection in FY00.
- Flight Validation: Complete ST-5 Critical Design Review (CDR).

Data Sources

Detailed information on the Space Science missions and mission concepts discussed in this appendix can be found at http://spacescience.nasa.gov/missions/index.htm.

Performance data provided by cognizant NASA Headquarters program executives and project scientists. Other sources include:

- Information Systems: Virtual Observatory December 2000, Monthly Project Report; Virtual Mars January 2001 Project Report, with Rover animations
- High Performance Computing: FY 2002 President's Budget
- Explorer Program Technology: Project reports for all original investigations, retained in the Explorer Program Office

- Flight Validation: September 17, 2001, Confirmation Assessment Review maintained at the Goddard Space Flight Center (GSFC).

**Data Voids**

None

**Results**

The annual performance goal was not achieved. While the Information Systems program provided important new capabilities for Space Science in FY 2001, funding for High Performance Computing was redirected to support other higher priority programs. Explorer Program Technology investigations selected in FY 1999 are now providing new technological options for the next round of Explorer Program mission proposals.

- Information Systems: Achieved. The Virtual Observatory capability was successfully demonstrated at the NREN Gigabit Networking Workshop in November 2000. The Virtual Mars capability was successfully demonstrated in January 2001.
- High Performance Computing: No longer being pursued. Funding was terminated in FY 2002 to support other Space Science priorities. As part of the close-out plan, this effort was cancelled, and resources concentrated on capturing the results of the project to date for possible future use.
- Explorer Program Technology: Partially achieved. No additional awards were selected in FY 2000 due to redirection of funding to Explorer Program missions. Transfer of funds to the higher-priority missions in development was made necessary by commercial Pegasus launch vehicle failures. Forty-three of the 45 investigations selected in FY 1999 were completed. The investigators for the remaining two efforts requested no-cost extensions through the first quarter of FY 2002; these extensions were granted. Technologies developed through the completed investigations are being proposed to Explorer Program Announcements of Opportunity for space flight.
- Flight Validation: Not achieved. The CDR for ST-5 was delayed due to difficulty in securing a secondary launch vehicle. Project managers are currently working with the U.S. Air Force, establishing an agreement to fly NASA secondary payloads. The possibility of flying ST-5 as a secondary payload on a commercial mission is also being aggressively pursued. The CDR is currently scheduled for FY 2002.

**Assessment**

**Yellow**

**Action Plan**

Action plans include:

- Explorer Program investigators were granted no-cost extensions through the first quarter of FY 2002.
- ST-5 Critical Design Review is currently scheduled for FY 2002.

# Earth Science

**Strategic Goal 1**

Expand scientific knowledge by characterizing the Earth system.

**Annual Performance Goal 1Y1**

The ESE will successfully develop, have ready for launch, and operate instruments on at least two spacecraft within 10 percent of their schedules and budget to enable Earth Science research and applications goals and objectives.

Indicators

- The Earth Science Enterprise (ESE) will successfully develop, have ready for launch, and operate instruments on at least two spacecraft to enable Science research and applications goals and objectives.
- At least 90% of the total on-orbit instrument complement will be operational.

Data Sources

Program web sites and other sources include:

- A list of all Earth Science launches are available at http://gaia.hq.nasa.gov/ese_missions/default.cfm?transaction=Enter_ESE_Missions.
- In addition, the following web site offers a list of all operating satellites: http://gaia.hq.nasa.gov/ese_missions/lau_select.cfm.
- A search of satellite missions on this web site provides current instrument status. Moreover, this information is tracked and archived by the Earth Science Program Planning and Development Division.
- For launches, the Program Planning and Development Division maintains a mission status list that is updated and reported on monthly at the NASA Headquarters Center Program Review. The list is also updated monthly on the Earth Science web site.
- For operations, the Earth Science Program Planning and Development Division maintains a current instrument status list. The Division also maintains a mission schedule list that is validated by the Earth Science Deputy Associate Administrator for Programs on a monthly basis. Budgetary information is maintained by the Earth Science Resources Team.

Data Voids

None

Results

This goal was achieved in part and will be achieved in its entirety in FY 2002.

- First, NASA developed, launched, and operated the Earth Observing-1 (EO-1) technology demonstration mission. Launched on November 20, 2000, several instruments onboard were validated and are being commercialized by the private sector. EO-1 was developed within 117 percent of its budget and 113 percent of its schedule. Earth Science also developed and readied for launch the Quick Total Ozone Mapping Spectrometer (QuickTOMS). Unfortunately, QuickTOMS was lost in a commercial launch failure. Also, the organization developed and launched the Geostationary Operational Environmental Satellite-M (GOES-M) on a reimbursable basis with the National Oceanic and Atmospheric Administration (NOAA). GOES-M remains operational and NASA receives valuable data.

- Second, by the end of FY 2001, there were a total of 30 NASA-funded on-orbit instruments, 29 (or roughly 96 percent) of which remained functional throughout the fiscal year. Analysis indicates that overall Earth Science missions remained within 110 percent of their budget and schedules.

Assessment

Yellow

Action Plan

In FY 2001, three missions were developed and two were successfully launched and operated. EO-1 exceeded its budget and schedule and GOES-M was developed and launched on a reimbursable basis with NOAA. In FY 2002, this goal will be fully met with the planned launch schedule.

**Annual Performance Goal 1Y3**

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.

Indicators

- Develop a multiyear global time series of phytoplankton biomass and primary productivity for assessing interannual variability in marine ecosystems on regional scales and daily to interannual time scales. Collect near-daily global measurements of ocean chlorophyll and primary productivity using Moderate Resolution Imaging Spectroradiometer (MODIS) on the Earth Observing System Terra (EOS Terra) and EOS Aqua satellites, merged with Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data.
- Continue to refresh the global archive of 30-meter land imagery seasonally with Landsat-7.
- Use MODIS on Terra and Aqua to estimate the efficiency of the carbon uptake by phytoplankton (i.e., photosynthesis) for the first time. Also, demonstrate the value of such measurements in assessing carbon and nitrogen cycling in the open ocean by testing their utility in biochemical models.
- Estimate global carbon stocks and the role of land ecosystems, and evaluate human impacts on land cover changes. Develop the first global sample of vegetation height and vertical structure by using data from first Earth System Science Pathfinder (ESSP) mission, the Vegetation Canopy Lidar (VCL). Canopy height will be estimated to within 1 meter.

Data Sources

The following web sites provide mission status and research information:

- Aqua: Available at http://aqua.nasa.gov/
- MODIS: Available at http://modis-ocean.gsfc.nasa.gov/ and http://modisland.gsfc.nasa.gov/
- Landsat: Available at http://www.landsat.org/
- Carbon Cycle NRA: Available at http://research. hq.nasa.gov/code_y/nra/current/NRA-00-OES-08/index.html.

Information on the resulting data and launch information is publicly available on the web sites listed above. The goal data are verified by the availability of continually updated data accessible from the web sites listed above.

Data Voids

None

Results

This goal was not met in FY 2001 but will be met approximately 6 months after the planned launch of the EOS Aqua spacecraft in Calendar Year 2002. Despite the mission delay, significant scientific progress was made towards developing, analyzing, and documenting multiyear data sets.

- First, Earth Science made progress in developing a multiyear global time series of phytoplankton biomass and primary productivity for assessing interannual variability in marine ecosystems on regional scales and daily to interannual time scales. MODIS data were being processed and readied for merger with SeaWiFS data. The indicator will be achieved in FY 2002 when Aqua is launched and its resulting data are processed. Meanwhile, researchers are working on improving and validating the algorithms for MODIS on EOS Aqua.
- Second, the global archive of 30-meter land imagery was refreshed with Landsat-7 data.
- Third, new fluorescence images from MODIS on Terra have been developed and made publicly available that demonstrate the signal in fluorescence and its relationship to productivity in U.S. coastal waters. One full year's worth of data was ready in November 2001. The application of these measurements to carbon and nitrogen cycling is being demonstrated. This indicator was also hampered by the Aqua launch delay but significant science did occur and the indicator will be fully realized in FY 2002.
- Fourth, the first global sample of vegetation height and vertical structure was not possible without the launch of the Vegetable Canopy Lidar (VCL). However, several research proposals approved in FY 2001 under a NASA Research Announcement on carbon cycle science will provide a rough estimation of global carbon stocks and the role of land ecosystems, and an evaluation of human impacts on land cover changes.

Assessment

**Yellow**

Action Plan

Though the goal was not specifically achieved, NASA continued to refresh multiyear data sets using MODIS data from Terra, as well as data from SeaWiFS and Landsat. The launch of Aqua in FY 2002 will allow NASA to add a fourth multiyear data component and the goal will be met.

**Annual Performance Goal 1Y4**

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.

Indicators

- Through incorporation of data from field experiments and satellite data analysis funded by the Biology and Biogeochemistry of Ecosystems and the Global Carbon Cycle research and analysis programs; improve, by at least 15%, the ecological models needed to predict ecosystem responses to global environmental changes.

This work will be done by NASA-funded investigators at universities and Government laboratories.

- Provide information to understand remotely sensed observations of productivity that will be useful for improved prediction and management of food and fiber production. This will be accomplished by extending the long-term 1-4 km satellite record of global terrestrial productivity and its seasonal and interannual dynamics that was begun with the Advanced Very High-Resolution Radiometer (AVHRR). Continued data sets with the near-daily global measurements from instruments on the EOS Terra spacecraft, using primarily the MODIS instrument.

Data Sources

Program web sites and other sources include:

- Data on the Boreal Ecosystem - Atmosphere Study (BOREAS) are available at http://www-eosdis.ornl.gov/ (under "Available Data," select BOREAS and BOREAS Follow-on).
- BOREAS publications are available at http://boreas.gsfc.nasa.gov/html_pages/boreas_home.html (under "Resources Available," select BOREAS publications).
- The MODIS data and data products are physically archived at the Goddard Space Flight Center. They can be searched and ordered through this web site: http://redhook.gsfc.nasa.gov/~imswww/pub/imswelcome/.
- Results are considered sufficiently valid for reporting and use once they have been accepted for publication in peer-reviewed literature. Data are considered valid once an analysis of calibration and validation are completed and the results are published. Verification of both requires the test of time, use, and acceptance by others, and other studies able to duplicate or confirm the analyses. All of the listed results are documented in several published papers in peer-reviewed scientific literature. The citations are available on file at NASA Headquarters with the Terrestrial Ecology program manager.

Data Voids

None

Results

This goal was met by achieving both indicators.

- First, results from the BOREAS field experiment have dramatically improved the accuracy of weather forecasts for the region and enabled ecosystem model outputs to agree with actual measurements. In addition, 3 years of well-calibrated, validated SeaWiFS data were used to compute, for the first time, a series of oceanic and terrestrial productions, that accurately portray seasonal and interannual variability. Strong El Niño/La Niña related differences were quantified. These model results set the baseline against which any future model improvements must be judged. These results, while difficult to quantify as a percentage increase, greatly exceed a 15-percent improvement.
- Second, MODIS data are archived and are contributing to continuity of the global satellite data record. New global terrestrial productivity data products are becoming available from MODIS and other satellite sensors. Extending this record is an important step in documenting ecosystem variability and supporting the modeling and prediction processes.

Assessment

**Green**

**Annual Performance Goal 1Y5**

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.

Indicators

- Resolve the wide disparity of precipitation estimates that currently exists, to within 20 percent, thus improving NASA's understanding of the global water cycle. The Tropical Rainfall Measuring Mission (TRMM) will obtain accurate maps of the diurnal cycle of precipitation and, in conjunction with a 10+ year reanalysis of Special Sensor Microwave Imager (SSMI) data, set a benchmark for tropical precipitation.
- Decrease the uncertainty in determinations of radiation forcing and feedback, and thereby increase accuracy in NASA's knowledge of heating and cooling of the Earth's surface and its atmosphere. 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 Earth Observing System (EOS) Terra satellite, respectively.

Data Sources

Program web sites and other resources include:

- Mission and research information on the Tropical Rainfall Measuring Mission and Terra are available at http://trmm.gsfc.nasa.gov/ and http://terra.nasa.gov/, respectively.
- The continued availability of TRMM and Terra data verifies this goal. Results from the TRMM research are summarized in December 2000 issue of the *Journal of Applied Meteorology*, available at http://ams.allenpress.com/amsonline/?request=get-toc&issn=1520-0450&volume=039&issue=12.
- Results from the Terra instrument research, particularly using CERES data, appeared in the September 5, 2001, issue of the *Journal of Climate*.

Data Voids

None

Results

This goal was met by achieving both indicators.

- First, data from TRMM led to a better understanding of the global water cycle by helping to resolve the wide disparity of precipitation estimates that currently exist. This became possible as NASA continued to combine TRMM results with Special Sensor Microwave Imager results for a 10+ year record of tropical precipitation estimates.
- Second, a better understanding of the heating and cooling of the Earth's surface and atmosphere is an important variable in understanding the global water cycle. Furthering the understanding of this element, NASA continued the analysis of data from MODIS, MISR, and CERES instruments, all onboard the EOS Terra satellite.

The goal of increasing Earth Science's understanding of the global water cycle by improving multiyear data sets was achieved through cumulative work using TRMM and Terra data.

Assessment

**Green**

**Annual Performance Goal 1Y6**

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.

Indicators

- Improve current understanding and model the large-scale effects of clouds in climate. Complete collection and processing of satellite data needed for the multi-decadal global cloud climatology being developed under the International Satellite Cloud Climatology Project (ISCCP).
- Validate parameterizations of Earth's radiative processes in models that simulate the cycling of fresh water through Earth's atmosphere. Complete a decadal Surface Radiation Budget climatology.
- 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. Soil moisture is an important land surface state variable, currently unmeasured at large spatial scales, that affects weather and climate.

Data Sources

Program web sites and other sources include:

- Information on the progress of the Cloud Project is available at http://isccp.giss.nasa.gov. This web site gives up-to-date progress and includes accuracy and precision of the data. This work is conducted through the Goddard Institute for Space Sciences.
- A progress report on the Surface Radiation Budget is available at http://srb-swlw.larc.nasa.gov/Pilot_homepage.html.
- The Distributed Active Archive Center at NASA's Langley Research Center maintains this data. Information on the progress of soil moisture is available at http://hydrolab.arsusda.gov/sgp97/ and http://hydrolab. arsusda.gov/sgp99/.
- NASA's progress and success in soil moisture research has been highlighted in specific meetings hosted by the American Geophysical Union. Also, numerous publications by researchers show data validity in achieving the indicator.

Data Voids

None

Results

This goal was met by achieving all three indicators.

- First, Earth Science continued work in the middle of the 3-4 year International Satellite Cloud Climatology Project. This 20-year climatology project will enable modeling simulations and predictions. NASA is now processing all collected data. Analysis was completed for the period of 1983-1993 and will be complete through 2000 by end of FY 2002.
- Second, the Agency continued to validate parameterizations of Earth's radiative processes in models that simulate the cycling of fresh water through Earth's atmosphere. Specifically, Earth Science completed the first generation of the multiyear Surface Radiation Budget.

- Third, the program furthered preparation for a space-flight trial of soil moisture by demonstrating the capability to diagnose soil moisture from airborne platforms over a variety of landscapes. For example, researchers have analyzed data over forests, agricultural areas, and grasslands through the Southern Great Plains Experiments. In addition, researchers are preparing for analysis and calibration of soil moisture data from sensors aboard Earth Observing System Aqua.

Assessment

**Green**

**Annual Performance Goal 1Y7**

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.

Indicators

- Complete detailed mapping of thinning/thickening rates for all major ice catchments on the Greenland Ice Sheet. This will serve as a baseline for future satellite-based surveys, to determine the behavior of the ice sheet and its influence on global sea level change. Use airborne laser altimeter data and analysis from the Climate Variability and Prediction Program.
- Use Jason-1 satellite data to continue the measurement of ocean basin-scale, sea-level variability and reducing errors to less than 3 centimeters (cm).
- Provide a quantitative understanding of the solar forcing of Earth's climate. Continue acquisition of a total solar irradiance dataset for the complete period of maximum solar activity. Continue the high precision, multi-decadal record of total solar irradiance measurements towards capturing three solar cycles. Enabled by the launch of the Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSAT) in FY00.

Data Sources

Program web sites and other sources include:

- A list of various NASA data sets relevant to these studies are accessible through the National Snow and Ice Data Center at http://nsidc.org/NSIDC/CATALOG/ENTRIES/nsi-0095.html.
- The Climate Variability and Prediction Program maintains a database accessible at http://www.clivar.org/.
- Results and data based on the airborne laser altimetry are available at http://aol.wff.nasa.gov/html/graphics_library/aoltm_science data/icesheet.html.
- The Jason-1 launch status is available at http://gaia.hq.nasa.gov/ese_missions/launch.cfm?lau_id=12.
- TOPEX/Poseidon and Solar Irradiance mission and research information can be found at http://podaac.jpl.nasa.gov/toppos/index_old.html and http://acrim.jpl.nasa.gov/, respectively. The Solar Irradiance web site gives up-to-date progress, including the accuracy and availability of the data. The Oceans satellite, however, has yet to be launched.
- Analysis results of the Greenland ice sheet were published in the July 20, 2000, issue of *Science* magazine. Subsequent analyses are in print in a special issue of the *Journal of Geophysical Research*, dedicated to NASA's research program in Greenland.

Data Voids

None

Results

This goal was met by achieving two of three indicators.

- First, Earth Science used airborne laser data and analysis and complementary data and analysis to complete a detailed mapping of the thickening and thinning rates on the Greenland ice sheet.
- Second, although the launch of Jason-1 was delayed, the measurement of ocean basin-scale sea-level variability continues uninterrupted with the Ocean Topography Experiment (TOPEX/Poseidon) satellite. Current plans are to replace the 9-year old TOPEX/Poseidon with Jason-1 after flying them in formation to validate Jason-1 data.
- Third, ACRIMSAT provides data on total incoming radiation. With this data, Earth Science continues to acquire a total solar irradiance data set and a multidecadal record of total solar irradiance measurements.

Assessment

**Green**

**Annual Performance Goal 1Y8**

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 area.

Indicators

- Develop and [*sic*] the capability to measure and diagnose open ocean variations in salinity by 0.1 practical salinity unit (psu) in preparation for a space-based system.
- Improve the understanding and modeling of the aerosol radiative forcing of climate and its anthropogenic component. Develop and validate aerosol retrieval and cloud screening algorithms, and processing of satellite data and transport model evaluations for the 20-year climatology of aerosol optical thickness and particle size.
- Demonstrate the experimental seasonal climate predictions based on observations from operating satellites. Use next-generation computing systems and new coupled air-ocean-land-ice models, incorporating all available satellite observations (e.g., Ocean Topography Experiment (TOPEX), Jason, Seawinds, Tropical Rainfall Measuring Mission (TRMM), Sea-viewing Wide field-of-view Sensor (SeaWIFS), Moderate Resolution Imaging Spectroradiometer (MODIS) of key ocean surface parameters such as wind vectors and altimetry.
- Enhance the accuracy of long-term climate variability and change models.

Data Sources

Program web sites and other sources include:

- Information and algorithms on Aerosol and Cloud Screening are available at http://isccp.giss.nasa.gov/. This web site gives up-to-date information, including accuracy and availability of the data.
- Progress on climate modeling and forecasts related to experimental seasonal climate predictions can be tracked at http://www.giss.nasa.gov/research/modeling/ and http://nsipp.gsfc.nasa.gov/exptlpreds/exptl_preds_main.html.

- The development of a subset of these forecasts is also documented in NASA *Tech Memos.* # 04606, vol. 17, 18, and 21, plus a NASA Seasonal to Inter-annual Prediction Project Progress Report. Almost all of the model improvements described in this indicator are supported by peer-reviewed articles.
- The solicitation results for Ocean Salinity will appear in a special issue of the *Journal of Geophysical Research* in FY 2002, entitled, "The Role of Salinity on Upper Ocean Dynamics, Air-Sea Interaction and Climate," by Guest Editor Gary Lagerloef.

Data Voids

None

Results

This goal was met by achieving three of four indicators.

- First, Earth Science issued an Earth System Science Pathfinder research solicitation for continued development of the capability to measure and diagnose open ocean variations in salinity. This indicator will be achieved through ongoing research and will be reported in FY 2002.
- Second, Earth Science improved the understanding and modeling of aerosol radiative forcing of climate and its anthropogenic component by developing aerosol retrieval and cloud screening algorithms. These algorithms are being validated through research grants funded through the end of FY 2001. This work will be incorporated into the 20-year climatology.
- Third, the demonstration of experimental seasonal climate predictions based on new observations is being pursued. TOPEX, TRMM, SeaWiFS, and MODIS data sets were used. NASA's Seasonal to Interannual Prediction Project has made substantial advances in improving the model forecast and using satellite data and its product for initializing and validating model-skills. The program has developed the capability to routinely make monthly experimental seasonal climate predictions. A major advance this past year was the introduction of ensemble forecasts to assess the forecast reliability over the past 5 years. Substantial progress was made over the past year on many aspects of the performance of the coupled model, on the forecasts, and on the ocean assimilation to incorporate satellite altimetric data. These were documented in the NASA Season to Interannual Prediction Project Progress Report, July 2001.
- Fourth, on the longer; i.e., global change time scale, the global model at the Goddard Institute for Space Studies underwent significant improvements in its resolution and accuracy. These improvements, documented in peer-reviewed scientific literature, include methane modeling, dynamic vegetation modeling, the role of the stratosphere in Northern Hemisphere climate, radiative effects of stratospheric water vapor, sulfur chemistry, and indirect aerosol forcing, as well as improved tropospheric chemistry modeling.

Assessment

**Green**

**Annual Performance Goal 1Y9**

Increase understanding of the dynamics of atmospheric composition by developing, analyzing, and documenting multiyear data sets and meeting at least 4 of 5 performance indicators in this research area.

Indicators

- Provide continuity of multi-decadal total ozone concentration measurements to aid in characterization of long-term evolution of ozone and enable assessment of ozone recovery processes.
- Continue to monitor atmospheric concentrations of chlorofluorocarbons and new industrial substitutes to understand their impact on ozone concentration.
- Develop a comprehensive climatology of high-resolution ozone vertical distribution in the southern subtropics. This climatology will be used to verify the quality of experimental algorithms used to obtain tropospheric ozone from Total Ozone Mapping Spectrometer (TOMS) data.
- Characterize long-term evolution and interannual variability in high latitude ozone, aerosol, and polar stratospheric cloud profiles.
- Obtain the first measurement of sunrise-to-sunset variations in global ozone aerosol distributions. Also, obtain the first daily diurnally-integrated estimates of surface Ultraviolet (UV) radiation using satellite data for the entire sunlit Earth.

Data Sources

Current mission and research information web sites include:

- TOMS-EP: Available at http://toms.gsfc.nasa.gov/eptoms/ep.html
- Atmospheric Gases: Available at http://agage.eas.gatech.edu/Data.htm
- Southern Hemisphere: Available at http://hyperion.gsfc.nasa.gov/Data_services/shadoz/frame_home.html
- Polar Ozone: Available at http://wvms.nrl.navy.mil/POAM/poam.html
- Triana: Available at http://triana.gsfc.nasa.gov/home/ (This mission was not launched).

Metric data can be validated through the continued availability of data accessible from the following web sites:

- Column Ozone Concentration: Available at http://toms.gsfc.nasa.gov/index.html
- Chlorofluorocarbons and new industrial substitutes: Available at http://cdiac.esd.ornl.gov/pns/pns_main.html
- Tropical tropospheric ozone: Available at http://hyperion.gsfc.nasa.gov/Data_services/shadoz/Sites2.html
- High latitude ozone, aerosol, and polar stratospheric cloud profiles: Available at http://wvms.nrl.navy.mil/POAM/poam.html and http://www-sage2.larc.nasa.gov/.

Data Voids

None

Results

This goal was met with the achievement of four of five indicators.

- First, continuity of multidecadal total ozone concentration was provided through the use of data from TOMS-EP and the NOAA Solar Backscatter UltraViolet 2.
- Second, the program furthered its understanding of the impact of chlorofluorocarbons and new industrial substitutes on ozone concentration through the NASA Advanced Global Atmospheric Gases Experiment network.

- Third, Earth Science continued to verify the quality of experimental algorithms used to obtain tropical tropospheric ozone information by continuing to fund and expand the Southern Hemisphere Additional Ozonesondes program.
- Fourth, using polar ozone and aerosol measurement data, the team continued to help characterize the long-term evolution and interannual variability in high latitude ozone, aerosol, and polar stratospheric cloud profiles.
- Fifth, without the launch of Triana, NASA scientists were unable to obtain the first measurement of sunrise-to-sunset variations in global ozone aerosol distributions, and to obtain the first daily diurnally-integrated estimates of surface ultraviolet radiation using satellite data for the entire sunlit Earth. This indicator was not met.

Assessment

**Green**

**Annual Performance Goal 1Y10**

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.

Indicators

- Provide increased prognostic ability for Northern Hemisphere high latitude ozone loss in an atmosphere perturbed by an increased abundance of greenhouse gases. This will be accomplished via a comprehensive analysis of data from the Stratospheric Aerosol and Gases Expiriment (SAGE) III Ozone Loss and Validation Experiment (SOLVE) campaign.
- 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. This will be accomplished via use of the Measurements of Pollution in the Troposphere (MOPITT) instrument aboard the Earth Observing System (EOS) Terra satellite.
- 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. Conduct the Transport and Chemical Evolution over the Pacific (TRACE-P) airborne campaign using DC-8 and P3-B together with satellite data and chemistry/transport models.

Data Sources

Program web sites and other sources include:

- SOLVE campaign information is available at http://cloud1.arc.nasa.gov/solve/.
- Information on MOPITT is available at http://eos-am.gsfc.nasa.gov/mopitt.html.
- TRACE-P is managed by the Global Tropospheric Experiment Project Office at NASA Langley Research Center, Atmospheric Sciences Competency. Information on TRACE-P is available at http://www-gte.larc.nasa.gov/gte_fld.htm#TRACE.
- Data on MOPITT are also available through the NASA Langley Distributed Active Archive Center.
- Data analysis results from the SOLVE campaign will be published in a special edition of the *Journal of Geophysical Research* in the near future.

Data Voids

None

Results

This goal was met by achieving all three indicators.

- First, NASA Earth Science provided increased prognostic ability for Northern Hemisphere high latitude ozone loss by completing the first round of analysis of data from the SOLVE campaign.
- Second, the team used data from the MOPITT instrument aboard the EOS-Terra satellite to provide improved assessment of the role of the global budget of carbon monoxide and methane. This will lead to the development of the first global climatology of carbon monoxide and total column methane. Processing of total column carbon monoxide was completed. Data are available for total column methane, and given the necessary 2- to 3-month period for processing, the complete set of FY 2001 data will be available through the NASA Langley Distributed Active Archive Center.
- Third, the TRACE-P airborne campaign was successfully completed and has added significantly to the understanding of the 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. Data analyses are ongoing.

Assessment

**Green**

**Annual Performance Goal 1Y11**

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.

Indicators

- Enable near-real-time assessment of ground deformation for disaster response after earthquakes, continuous monitoring of large structures over time to detect subsidence or landslide vulnerability, and swelling of the ground as a precursor to explosive volcanic eruptions. Provide daily orbit solutions for Global Positioning System (GPS) constellation as a basis for cm-level satellite orbit determinations and mm-level ground based GPS positioning and navigation.
- Conduct global geologic and geomorphic process studies, comparative analysis, improved mapping of terrain features such as floodplains, and input to models for improvement of hazard assessment/mitigation. Conduct analysis of near-global Shuttle Radar Topography Mission (SRTM) 30-meter topographic data.

Data Sources

Program web sites and other sources include:

- Information on the Southern California Integrated GPS Network (SCIGN) is available at http://www.scign.org/ and http://scign.jpl.nasa.gov.
- The Jet Propulsion Laboratory provides daily cm (~5 cm) level satellite orbit determinations for the GPS constellation. This information is available at http://www.scign.org/.
- GPS data are also available through File Transfer Protocol from the Jet Propulsion Laboratory at http://sideshow. jpl.nasa.gov/mbh/series.html.

- Also, numerous examples of the utility of SRTM data are provided to the general public over the SRTM web site http://www.jpl.nasa.gov/srtm/, since the flight mission in February 2000.

Data Voids

None

Results

This goal was met by achieving both indicators.

- First, Earth Science improved NASA's ability to detect and understand earthquakes, landslides, and volcanic eruptions through space-based observations by completing the installation of the Southern California Integrated GPS Network (SCIGN), in which NASA was the lead organization for implementation. The network contains 250 geodetic GPS receivers that provide millimeter scale measurement of the crustal deformation in Southern California. SCIGN is moving toward ever more rapid data collection and processing at the millimeter level. Of note, real-time global decimeter scale positioning was implemented through a commercial collaboration with John Deere. The software for this system won NASA's Software of the Year Award for 2001.
- Second, using SRTM data, studies and comparative analyses were conducted, mapping of terrain features was improved, and some input to models for improving hazard assessment and mitigation was completed. Toward this end, SRTM improved current elevation maps by 80 percent. SRTM data are providing valuable information to the United States national security community. The dissemination of global data are under review due to national security issues.

Assessment

**Green**

**Annual Performance Goal 1Y12**

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.

Indicators

- Improve understanding of geodynamic processes and allow continous observations, improve data processing efficiency and reduce operational costs by 20%. Complete the Very Long Baseline Interferometry (VLBI) Mark IV Correlator upgrade.
- Provide a basis for future tectonic modeling and earthquake vulnerability assessment. Complete installation of the Southern California Integrated GPS Network (SCIGN) array of 250 precision Global Positioning System (GPS) locators/receivers for monitoring strain accumulation in Southern California.

Data Sources

Program web sites and other sources include:

- Information on the Mark IV Correlator Upgrade can be found at http://www. vsop.isas.ac.jp/. Processing improvements with the Very Long Baseline Interferometry Mark IV Correlator Upgrade exceed 50 percent and its budget is fixed. Given this efficiency improvement, fixed funding and inflation, operational costs were reduced by at least 50 percent.
- Information on SCIGN is available at http://www.scign.org/ and http://scign.jpl.nasa.gov (The Jet Propulsion Laboratory is providing the 5 millimeter data). GPS

data are available via FTP from the Jet Propulsion Laboratory at http://sideshow.jpl.nasa.gov/mbh/series.html.

**Data Voids**

None

**Results**

This goal was met by achieving both indicators.

- First, NASA Earth Science improved data processing efficiency and reduced operational costs by more than 20 percent by completing the Very Long Baseline Interferometry Mark IV Correlator Upgrade. The new correlator can run multiple observing sessions simultaneously. This previously required sequential operations. The VLBI budgets are fixed and with increased efficiency exceeding 20 percent, inflation alone indicates that operational costs have been reduced by at least 20 percent.
- Second, NASA engineers provided a basis for future modeling and vulnerability assessment of earthquakes by completing installation of the SCIGN array of 250 precision GPS locators/receivers. This data will greatly enhance NASA's ability to model earthquakes and project potential trouble spots.

**Assessment**

**Green**

## Strategic Goal 2

Disseminate information about the Earth system.

### Annual Performance Goal 1Y2

Successfully disseminate Earth Science data to enable our science research and applications goals and objectives by meeting all performance indicators in this research area.

**Indicators**

- Make available data on prediction, land surface, and climate to users within 5 days.
- Increase by 20% the volume of data archived compared to FY00 (annual performance goal = 442 terabytes).
- Increase the number of distinct Earth Observing System Data and Information System (EOSDIS) customers by 20% compared to FY00 (annual performance goal = 1.5 million).
- Increase products delivered from the Distributed Active Archive Centers (DAACs) by 10% compared to FY00 (annual performance goal = 5.4 million).
- 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 FY00. Implement user satisfaction.
- Decrease total percentage of order errors by 5% over FY00.

**Data Sources**

Program web sites and other sources include:

- Data files are available from the EOSDIS Science Operations Officer at vanessa.l.griffin.1@gsfc.nasa.gov.
- Summary level data for the Distributed Active Archive Centers (DAACs) are located at ftp://eos.nasa.gov/EosDis/Daacs/Statistics and http://ivanova.gsfc.nasa.gov/charts.

- Federation ESIP metrics information can be found at http://glcf.umiacs.umd.edu/documents/eval/.
- Statistics validating this metric are collected from the individual DAAC and ESIP researchers. It is then aggregated and archived by the Goddard Space Flight Center EOSDIS Project and publicly available at the web site listed above. Data are collected through several methods:

  Delivery time metrics are calculated from the time the user places an order until the order is shipped. The DAACs calculate the average delivery time for all media shipments. Delivery time for electronic deliveries is assumed to be one day (actually it is nearly instantaneous). Delivery times for data from EOSDIS Core System (software and hardware developed/bought by private sector deployed at four DAACs) via media were unavailable, because almost all Core System orders are shipped electronically. Earth Science has set the delivery time for all Core System data products to 1 day. The ESIP partners report the percentage of data products delivered within time thresholds (immediate, <3 days, <5 days, <10 days, <1 month and >1 month). The average delivery time is calculated by a weighted average of the DAAC and ESIP data. The median value is assumed to be less than 1 day because well over 70 percent of all products are delivered either electronically (from DAACs) or immediately (from ESIP). Volume of data archived is reported by the individual data centers. The ESIPs report the volume of data in their archives via the ESIP Metric reporting web site http://glcf.umiacs.umd.edu/documents/eval/. The DAAC data volumes (of data products available) are calculated from entries posted to the DAAC Science Data Plan home page, http://spsosun.gsfc.nasa.gov/spso/sdp/sdphomepage.html. The DAAC volumes are validated against system reports from the EOSDIS Core System (ECS) and V0 systems. Number of customers is calculated by automated scanning of customer contact logs, counting unique (for the year) email or customer user IDs. Product delivered counting is automated at the various data centers. DAAC metrics are automatically transferred to collection systems. ESIP partners enter their data manually onto the Federation Metrics web page. Favorable Customer Comment metrics are obtained by manually checking all customer emails and phone contact logs and counting contacts that were favorable. This methodology is necessarily subjective, as a determination of “tone” or “mood” of the customer must be made for each contact. Error metrics are calculated by looking at emails and phone contact logs to identify the number of data orders that had to be reshipped due to an error identified by a customer (e.g., data not received or received incorrect or corrupted data). Order problems that were identified and corrected prior to shipment are not counted in the metric. The error percentage is calculated by dividing the number of errors by the total number of orders.

**Data Voids**

None

**Results**

This goal was met by achieving all six indicators.

- First, the average delivery time for all products from Earth Science DAACs and ESIPs was 2.7 days, while the median delivery time for user orders was reduced to less than 1 day. Over 78 percent of Earth Science data products are shipped via electronic means with nearly instantaneous delivery.

- Second, at the end of FY 2001, program data centers had archived over one petabyte (1024 terabytes) of data (more than double the goal of 442 terabytes).
- Third, NASA increased the number of distinct users to 2.3 million customers. Of this number, 700,000 (30 percent of the total) were customers served by the Federation ESIPs.
- Fourth, averaging a delivery of roughly 1.2 million data product deliveries per month, Earth Science exceeded its goal of 5.4 million deliveries. The DAACs and ESIPs delivered just under 15 million science and information products to users in FY 2001.
- Fifth, the data center also made significant progress in improving user satisfaction. Earth Science implemented a basic user survey at 17 data centers and has plans to implement a comprehensive system-wide user survey in 2002. The center also received an increased number of favorable comments from users.
- Sixth, the percentage of order errors was reduced significantly (by nearly 20 percent) with an error-free rate of over 99 percent.

Assessment

**Blue**

## Strategic Goal 3

Enable the productive use of Earth Science Enterprise science and technology in the public and private sector.

### Annual Performance Goal 1Y13

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.

Indicators

- Annually advance at least 25% of funded instrument technology developments one Technology Readiness Level (TRL).
- Develop advanced information systems technologies and concepts for processing, archival, access, and visualization of Earth Science data.
- Develop at least 3 technologies to demonstrate in space with the third Earth Observer New Millennium satellite.
- Transfer at least one technology development to a commercial entity for operational use.

Data Sources

Program web sites include:

- Information on the Instrument Incubator Program is available at http://www.esto.nasa.gov:8080/programs/iip/ and http://nais.msfc.nasa.gov/cgi-bin/EPS/synopsis.cgi?acqid=95775 (provides program information).
- There were 26 projects selected under a 1998 NASA Research Announcement (NRA-98-OES-05); details are available at http://esto-doc.gsfc.nasa.gov/documents/IIP/reference/nra_98_oes_05/index. htm.

- Documentation that nine of these projects advanced at least one Technology Readiness Level is held by the Goddard Space Flight Center Earth Science Technology Office. Information on the technology office is available at http://esto.gsfc.nasa.gov/.
- Additional information on Advanced Information Systems is available at http://sbir.nasa.gov and http://research.hq.nasa.gov/code_y/nra/current/CAN-00-OES-01/index.html (provides the research solicitations). The High Performance Computing and Communications Project Office at the Goddard Space Flight Center is currently developing a system to validate progress made through the research call by setting a series of milestones to be achieved before receiving further funding.
- Small Business Innovation Research is an Agency-wide program managed at Goddard Space Flight Center. Information on solicitations and selections can be found at http://sbir.nasa.gov/.
- Mission information for Earth Observing-3 (EO-3) can be found at http://nmp.jpl.nasa.gov/eo3/about/about.html. The seven EO-3 technologies are the Imaging Fourier Transform Spectrometer, a large focal plane imaging array with advanced cryogenic cooling, high speed signal processing to accommodate large data sets in real time, data compression for reduced downlink loading, autonomous pointing and attitude control, low power, radiation tolerant microelectronics, and light weight structures and optics.
- Mission information and updates for EO-1 are available at http://eo1.gsfc.nasa.gov/ and http://eo1.gsfc.nasa.gov/Technology/eo1Technology.html. EO-1 partnerships with commercial entities for the transfer of technology include Boeing, Lewis, Amoco Polymers, BF Goodrich, and Lockheed Martin.

### Data Voids

None

### Results

The development of new technologies is a fundamental objective for NASA's Earth Science program. In meeting this goal, all four indicators were achieved and three were exceeded:

- First, 9 of 26 (35 percent) Instrument Incubator Program technologies were advanced at least one technology readiness level. This exceeded the goal of 25 percent.
- Second, two advanced information systems technologies and concepts for processing, archival, access, and visualization of Earth Science data were developed. Researchers selected under a Cooperative Agreement Notice entitled, "The Increasing Inter-operability and Performance of Grand Challenge Applications in the Earth, Space, Life, and Microgravity Sciences" (CAN-00-OES-01), are working on the multiyear project seeking to integrate various climate models into one framework global climate model. Earth Science also participated in the Small Business Innovation Research program. This is an annual call for small businesses to receive funding for technology development. The office received 27 percent of the total NASA proposals for FY 2001. Both the research calls provide pieces leading to visualization of Earth Science data.

- Third, NASA developed seven technologies (including one new instrument) to demonstrate in space with the third New Millennium Earth Observing (EO-3) satellite. The technologies that EO-3 demonstrates will enable improvement in the general capability of future remote sensing satellites, as well as reductions in their cost. The technologies that EO-3 tests in space will also help revolutionize the observation and prediction of the weather, enabling scientists and meteorologists to forecast the weather with a new level of accuracy in the future, especially severe weather like hurricanes and storms.
- Fourth, at least two technology developments were transferred to a commercial entity for operational use. NASA, other Federal agencies, and commercial partners are working to validate all nine of the technologies aboard EO-1. As part of that partnership, after the technologies have been validated, the commercial partners can market them.

Assessment

**Blue**

**Annual Performance Goal 1Y14**

Provide regional decision-makers with scientific and applications products/tools by meeting at least 7 of 8 performance indicators for this applications research area.

Indicators

- Establish at least a second of seven Regional Earth Science Application Centers (RESACs) as a self-sustaining entity.
- Improve availability of Landsat data to State and local governments by producing a digital image database of all 50 states once every two years (first of two-year cycle).
- Develop capability to assess the vulnerability of fishing grounds due to water quality issues using remote sensing and ground based information.
- Develop experimental models to demonstrate an ability to improve forecast skill levels for projecting the paths of severe storms using satellite derived sea surface winds, precipitation & surface temperature from QuikScat, Tropical Rainfall Measuring Mission (TRMM), Seawinds, 1A, Terra, Ocean Topography Experiment (TOPEX) and Jason-1.
- Develop a prototype capability to monitor and predict the track of at least one key atmospheric pollutant.
- Develop a predictive capability for outbreaks of malaria in Central Africa.
- Initiate two applications research projects with the public and private sector to develop and assess techniques to monitor and verify carbon storage in vegetation and soils.
- Develop at least two new data products for routine decision-making by user organizations involved in Earth Science Information Partners (ESIP) Cooperative Agreements and the Agriculture, Forestry and Rangeland Cooperative Agreements and Grants.

Data Sources

Program web sites and other sources include:

- Primary data on sustainability come from RESAC quarterly and annual reports, available from the RESAC web site at http://www.esad.ssc.nasa.gov/resac/resacmain.asp.

A sample RESAC is available at http://resac.gis.umn.edu/. Sustainability progress is reported regularly to project managers through the RESAC quarterly progress reports, which can be obtained from Rodney McKellip at 228-688-2984.

- Landsat Data is available at http://landcover.usgs.gov/, http://edcw2ks15.cr.usgs.gov/lccp/mrlc2k/mrlc2k.asp and http://edcw2ks15.cr.usgs.gov/lccp/mrlc2k/mrlc2k_desc.asp (provides data availability information).
- The data set for the United States is being compiled and should be complete within the 2-year goal. As the scenes are processed and readied for distribution, they are accessible through the Internet. The address for the current listing of scenes and ordering information for available scenes is http://edc2ks15.cr. usgs.gov/lccp/mrlc2k/mrlc2k.asp.
- A number of oceanographic data sets is used in the fisheries model. While most of the data are satellite-derived, some data are collected in situ.
- Surface winds data links are available at http://manati.wwb.noaa.gov/doc/oceanwinds1.html, while other data are available at http://earth1.esrin.esa.it/ and http://www.ngdc.noaa.gov/NOAAServer/index.html.
- A five-page paper summarizing the fisheries project is available at http://www.deas.harvard.edu/~leslie/5Pager/afmis_5pager_final.html, as well as some example products, available at http://www.deas.harvard.edu/~leslie/RTDOC/products.html and http://afmis.cmast.umassd.edu.
- For forecasting, a CD-ROM highlighting the meeting results was produced and sent to all interested researchers. Copies are kept by the Global Data Integration and Validation Program Manager. Improved forecasting using space-based instruments was clearly demonstrated at the NASA Headquarters research review on July 20, 2001. One result was published in the September 2001 issue of the *Bulletin of the American Meteorological Society*. As for Atmospheric Pollutant, the data are held by the investigator responsible for the Satellite Data to Produce an Air-Pollution Haze and Inherent Health Risk Atlas over Densely Populated Areas (SAPPHIRE) Project. Questions regarding methodology and data may be directed to the investigator at sifakis@space.noa.gr.
- Data from the atmospheric pollutant study are contained in the SAPPHIRE Project, verifiable with the investigator at sifakis@space.noa.gr.
- Monthly risk maps are posted on the web site http://www.geis.ha.osd.mil/riftvalleyfever/index.htm.
- Rift Valley Fever (RVF) data are published regularly on the U.S. Department of Defense Global Emerging Infectious System web site.
- Information on Carbon Research is available at http://research.hq.nasa.gov/code_y/nra/current/NRA-00-OES-08/index.html (this web site provides a copy of the solicitation). The three projects selected under NRA-00-OES-08 for carbon research related to applications are Richard Birdsey, "Large Scale Validation of Carbon Stock and Flux Estimates from Remote Sensing"; Ingrid Burke, "Application of Remotely Sensed Imagery to Assessing the Probabilities and Carbon Consequences of Fire"; and Stuart Marsh, "Establishing a Basis for Carbon Management Policy at the State Level."

- Program information on Decision-Making Tools is available at http://www.esad.ssc.nasa.gov/ffars/ffarsmain.asp.
- The two tools developed by the U.S. Department of Agriculture are a rangeland analysis utilizing geospatial information science and a preliminary soil survey of Pinto Basin. The rangeland project can be viewed at http://ranges.geo.msu.edu, where a sampling of the products are available. The actual online product is password protected for access by range managers.

Data Voids

None

Results

In meeting this goal, seven of eight indicators were achieved.

- First, a second of seven RESAC was not established as a self-sustaining entity. However, RESAC is a 3-year project ending in 2002 and it is possible that a second RESAC may possibly become self-sustaining by that time. Moreover, there has been progress towards reaching this indicator. In FY 2000, the Great Plains RESAC (University of Kansas) created a small business (demonstrating that RESACs are creating self-sustaining spin-off organizations).
- Second, State and local government access to Landsat data was significantly improved. NASA provided funds for the United States Geological Survey to add Alaska and Hawaii to complete all 50 states. The Landsat-7 images for the common digital map are available for use by State, local, and tribal governments since late-Calendar Year 2001. Land cover products derived from the Landsat-7 data will be available in subsequent years. This will fulfill the 2-year goal.
- Third, remote sensing data were used to develop a capability to assess the vulnerability of fishing grounds due to water quality issues. In particular, a Harvard/University of Massachusetts-Dartmouth study of fish on George's Bank related remote sensing, field data, and historical data to map the likelihood of finding harvestable fish in any given area of the fishing grounds. The resulting model is being tested with a commercial fleet to predict stocking.
- Fourth, various space-based instruments were used to develop experimental models to demonstrate an ability to improve forecast skill levels for projecting the paths of severe storms. At the research review held at NASA Headquarters on July 20, 2001, various researchers highlighted ways in which they are using QuickScat, TRMM, SeaWinds, TOPEX/Poseidon, and EOS-Terra to meet this indicator.
- Fifth, a prototype capability to monitor and predict the track of at least one key atmospheric pollutant was developed. Specifically, a Fulbright scholar hosted by the Goddard Space Flight Center for collaboration and data sharing has developed a new methodology using the Landsat atmospheric signal to track air pollution over land/cities. This could lead to better air pollution data on densely populated areas of the world and could be used for decision-making and broadcast information purposes. The project is known as the Satellite Data to produce an Air Pollution Haze and Inherent health Risk Atlas over Densely Populated Areas (SAPPHIRE).
- Sixth, a predictive capability for outbreaks of RVF in Central Africa was developed. Risk maps have been published every month since FY 2000 and posted on the U.S. Department of Defense Global Emerging Infectious System web site. Risk products generated

are used by the World Health Organization as guidance to vaccinate animals in Botswana during growing season. NASA investigators provided data support to the Walter Reed Army Institute for Research during the outbreak of RVF in Saudi Arabia and Yemen.

- Seventh, three applications research projects with the public and private sector were initiated to develop and assess techniques to monitor and verify carbon storage in vegetation and soils. This indicator has been achieved through three projects selected under NASA Research Announcement, NRA-00-OES-08, for Carbon Research.
- Two new data products for routine decision-making by user organizations involved in Earth Science Information Partner (ESIP) Cooperative Agreements and the Agriculture, Forestry, and Rangeland Cooperative Agreements and Grants were developed, including the rangeland analysis tool and the preliminary soil survey of Pinto Basin. Results indicated a costs savings of 15 percent utilizing the digital methods and delivery of the official publication 1 year sooner than planned.

Assessment

**Green**

**Annual Performance Goal 1Y15**

Improve access to and understanding of remotely sensed data and processing technology by meeting 3 of 3 performance indicators in this area.

Indicators

- Foster applications of remote sensing data and processing technology by involving at least 20 states in using Earth Science observations, information through informational workshops.
- Increase the operational application of remote sensing technology by initiating at least ten joint Application Research pilot projects (5-year projects) with State and local governments addressing their specific needs as identified at planning work shops.
- Develop workforce skills needed in remote sensing, Geography Information System (GIS), and other attending technologies by implementing at least ten active student internships at the State and local level.

Data Sources

Program web sites and other sources include:

- Information on each of the workshops can be found at: www.westgis.com, www.nsgic.org, info@racne.org and www.rstc.msstate.edu. Informational workshops were convened in Sacramento and Lake Tahoe, California, New York, and Memphis, Tennessee. A report by Melanie Wallendorf and Ada Leung of the University of Arizona Department of Marketing found that the workshops significantly increased use of remote sensing data. The report is held by the Earth Science Applications Division Director.
- Pilot Projects are available at http://research.hq.nasa.gov/code_y/nra/current/BAA-01-OES-01/index.html. In response to the Broad Agency Announcement for State, Local and Tribal Governments, BAO-01-OES-01, 200 abstracts for pilot projects were received. By following the guidelines developed during the planning workshops, 39 abstracts were approved. Full proposals were requested from these successful proposals and received by July 16th. Fifteen proposals were accepted.

- As for internships, a list of awardees can be found at: http://www.spacecommerce.com/april_may_news/aprpage3.html.

Data Voids

None

Results

In meeting this goal, all three indicators were achieved:

- First, almost all 50 states (more than 500 participants) were involved in using Earth Science observations through four informational workshops. A survey conducted before the workshops were held found that 35 percent of those surveyed had never used satellite data. Following the workshops, that number fell to 20 percent.
- Second, 15 joint application research pilot projects (5-year projects) with State and local governments addressing their specific needs were initiated.
- Third, at least 19 active student internships were awarded in FY 2001 to develop workforce skills needed in remote sensing, Graphic Information Systems, and other attending technologies. NASA is collaborating with Governmental agencies, educational institutions at all levels, and trade associations to use existing education and training infrastructures to integrate geospatial workforce skills into existing educational programs. Additionally, the program will provide geospatial training to 500,000 K-12 students by 2003.

Assessment

**Green**

**Annual Performance Goal 1Y16**

Stimulate the development of a robust commercial remote sensing industry by meeting at least 4 of 5 performance indicators in this area.

Indicators

- Develop ten new market commercial products (e.g., oil spill containment software by EarthSat and map sheet products by Earth Resources Data Analysis System (ERDAS) Inc., in joint commercial applications research projects.
- Identify at least one new commercial source of science data as a result of the Scientific Data Purchase activities for Earth Science research and applications.
- Develop four new validated commercial information products as a result of verification and validation partnerships with the private sector and other users through the Mississippi State Commerce Initiative and the Space Act Agreement.
- Conduct Earth Observation Commercial Applications Program (EOCAP) Technology projects that result in ten prototype products that quantify the utility of Hyperspectral and Synthetic Aperture Radar (SAR) technologies and define future market requirements.
- Increase the cost share leveraging with companies, academia and other government agencies within the EOCAP and Affiliated Research Center (ARC) programs by 10%.

Data Sources

Program web sites and other sources include:

- A listing of the partner companies for commercial products can be found at http://www.spacecommerce.com/msci_companies/intro.html. Clicking on each company logo leads to a web site detailing the nature of that company's work. NASA awarded a contract to Orbimage on July 6, 2001, for the purchase of OrbView-4

Hyperspectral data. For scientific data purchase information, refer to contract number NAS13-01041.

- A listing of the companies involved in the Mississippi State Commerce Initiative and the Space Act Agreement can be found at: http://www.spacecommerce.com/msci_companies/intro.html. The list provides details of the cooperation with all the companies involved in the project to develop new commercial products.
- For EOCAP information access http://www.esad.ssc.nasa.gov/eocap/eocapmain.asp. In developing 12 prototype products to quantify the utility of Hyperspectral and Synthetic Aperture Radar technologies, four EOCAP-Synthetic Aperture Radar contractors developed products/services that are currently operational and are generating revenues (Northwest Research Associates, Ocean Imaging, Vexcel, i3; four other EOCAP-Synthetic Aperture Radars, Envisense, TSC, Kodak and ERIM, released prototype products/services to their end-user advisory panels for feedback, and four EOCAP-Hyper-spectral Investigators exceeded NASA's expectations by expanding their operational products/services offerings with innovative solutions using hyperspectral data (e.g. Spectral International, Applied Analysis, Inc., Yellowstone Ecosystems, and Opto-Knowledge).
- As for Cost Sharing, the ARC program manager maintains a file with FY 2000 and FY 2001 data. The ARC program includes eight state universities. Cost share leveraging increases ranged from 167 percent to 10 percent for an average of 39 percent. All data are maintained by the ARC program manager.

Data Voids

None

Results

In meeting this goal, four of five indicators were achieved.

- First, 10 new commercial market products were developed in joint commercial applications research projects.
- Second, as a result of the Scientific Data Purchase program for Earth Science research and applications, a new commercial source of science data was awarded to Orbital Imaging Corporation (Orbimage) for the purchase of OrbView-4 Hyperspectral Data on July 6, 2001.
- Third, two of four validated commercial information products were developed as a result of verification and validation partnerships with the private sector and other users through the Mississippi State Commerce Initiative and the Space Act Agreement. The Pan and Multispectral products from the IKONOS satellite were validated through aircraft under flight using the Advances Thermal and Land Application Sensor. The other two planned validations were Orbimage's OrbView-4 and Earthsat's QuickBird 2. However, the OrbView-4 was lost in a commercial launch failure on September 21, 2001, and DigitalGlobe (formerly Earthsat) launched Quick Bird 2 in October 2001. This indicator was not achieved.
- Fourth, 12 prototype products that quantify the utility of Hyperspectral and Synthetic Aperture Radar technologies and define future market requirements resulted from EOCAP Technology projects. This exceeded the Earth Science goal of ten products.

- Fifth, the cost share leveraging with companies, academia, and other government agencies within the ARC programs was increased by 39 percent.

Assessment

**Green**

**Annual Performance Goal 1Y17**

Provide remote sensing tools and capabilities that could enable efficiencies in food and fiber production with the aid of remote sensing by meeting the performance indicator in this area.

Indicators

Conduct at least 30 joint applications research endeavors in conjunction with the U.S. Department of Agriculture (USDA).

Data Sources

Program web sites and additional sources include:

- The programs described above are detailed at www.ag2020.net, www.esad.ssc.nasa.gov/ffars/ffarsmain.asp, www.esad.ssc.nasa.gov/resac/resacmain.asp, and www.rstc.msstate.edu.
- Thirteen projects were conducted within the Food and Fiber Applications of Remote Sensing program.
- Ten projects were recently selected out of the FY 2001 Application of Geospatial and Precision Technologies solicitation that was part of the larger Initiative for Future Agriculture and Food Systems program of the U.S. Department of Agriculture.
- Six projects currently active in the Regional Earth Science Application Center program have an operational division of the U.S. Department of Agriculture as an end-user partner in the consortium, including the U.S. Forest Service, the U.S. Foreign Agricultural Service, and the Natural Resource Conservation Service.
- Two of NASA's most significant projects in the Ag2020 program have several ongoing field experiments in direct collaboration with the U.S. Department of Agriculture scientists. These partnerships are the commercial applications technology collaboration with the Institute for Technology Development's Spectral Vision Division and the Mississippi State University Remote Sensing Technology Center.

Data Voids

None

Results

This goal was met by achieving the indicator. At least 30 joint applications research endeavors in conjunction with the U.S. Department of Agriculture were conducted. Thirteen were conducted through the Food and Fiber grants, seven with the Future Agriculture and Food System, five through the Ag20/20 project, and five with Mississippi State University.

Assessment

**Green**

**Annual Performance Goal 1Y18**

Increase public understanding of Earth system science through formal and informal education by meeting at least 3 of 4 performance targets in this area.

Indicators

- Continue 90 existing grants and award 50 new graduate student research and education grants.
- Continue 17 early career grants in research/education and initiate at least two new collaborative projects in the Earth Science international young investigator program.
- Conduct at least 400 workshops training K-12 teachers of Office of Earth Science (OES) education products; a 13% increase over FY 2000.
- Increase participating teachers in Global Learning and Observation to Benefit the Environment (GLOBE) to 13,800, and increase participating countries to 87.

Data Sources

Program web sites and other sources include:

- Information on Education Grants is available at http://research.hq.nasa.gov.
- In addition, further information on Education Programs can be found at http://education.gsfc.nasa.gov/.
- The Earth Science Applications Division is responsible for awarding fellowships and grants to ensure qualified candidates. Records are held by that division. Validation of the teacher education data is with the Earth Science Education Implementation Office at the Goddard Space Flight Center.

Data Voids

None

Results

This goal was met by achieving all four indicators with two exceeded.

- First, 142 grants were funded this year (exceeding the goal of 140). Eighty-seven existing grants were continued (instead of the planned 90 due to early graduation) but this is offset by a higher number (55) of new students selected for new awards this year.
- Second, 33 early career grants were awarded and the international young investigator program was eliminated.
- Third, at least 482 workshops training K-12 teachers on Earth Science education products were conducted and over 9,295 K-12 educators participated.
- Fourth, the number of participating teachers in the GLOBE program increased to approximately 13,800, and participating countries increased to 97.

Assessment

**Green**

# Biological and Physical Research

*Note: NASA created the Biological and Physical Research (BPR) Enterprise in October 2001. The new Enterprise inherited responsibility for reporting performance goals established by the Office of Life and Microgravity Sciences and Applications within the Human Exploration and Development of Space (HEDS) Enterprise. The new BPR Enterprise successfully fulfilled the commitments of its predecessor organization and will report against the goals of the HEDS Enterprise in this FY 2001 report.*

**Strategic Goal 1**

Expand the Space Frontier.

**Annual Performance Goal 1H1**

Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 orbiter and lander missions.

Indicators

- Complete testing and delivery for spacecraft integration for the radiation monitoring experiment hardware (Martian Radiation Environment Experiment - MARIE).
- Complete testing and delivery for spacecraft integration for the soil and dust analysis experiment (Mars Environmental Compatibility Assessment - MECA).

Data Sources

Results are documented in final reports for the MARIE hardware.

Data Voids

None

Results

NASA's experiments planned for Mars Surveyor Program 2001 missions were designed to explore radiation and dust environments associated with Mars exploration, and to demonstrate technologies for using existing resources on Mars (e.g., the atmosphere) to support future missions. The information from these experiments will assist in the development of safe mission designs for the human exploration of Mars.

NASA successfully completed testing and delivery of a radiation monitoring experiment, and has successfully integrated it onto the spacecraft.

The lander portion of the Mars Surveyor Mission was cancelled for reasons unrelated to this annual performance goal. Work was therefore halted, following final testing of the hardware, on an experiment which would have analyzed Martian dust and soil, as well as an experiment on producing propellants from the Martian atmosphere. This hardware is in bonded storage and may be flown on later missions.

No plan currently exists for completing the lander experiments; however, NASA remains committed to leveraging robotic mission opportunities as a precursor to human exploration.

Assessment

N/A

**Strategic Goal 2**

Expand scientific knowledge.

**Annual Performance Goal 1H3**

Support an expanded, productive research community to include 975 investigations by 2001. HEDS seeks to prepare and support a research community to take full advantage of research opportunities in the coming era of orbital research, including support for 975 investigations in 2001.

Indicators

- Expand support to approximately 975 investigations (from 877 reported in FY 99).
- Publish abstracts and reports of progress for over 90% of FY 2000 research investigations (tasks) and make this publication available on the Internet.
- Support publication of approximately 1500 journal articles in refereed journals.
- Support emergent microgravity research programs in biophysics and tissue engineering by selecting up to 10 new investigations.

Data Sources

Data sources include reviews of investigation count spread sheets, the Office of Biological and Physical Research task book, and e-mail correspondence were held with NASA Headquarters program scientists and responsible officials and the NASA Peer Review Services and the contractor.

Data Voids

None

Results

NASA supported 988 investigations in 2001, including 17 investigations in biophysics and tissue engineering (536 physical science investigations, 291 bioastronautics investigations, and 161 fundamental space biology investigations). The office supported investigators published approximately 1,400 journal articles. Ninety-five percent of FY 2000 research investigations were documented in the task book and made available on the Internet.

Assessment

**Green**

**Annual Performance Goal 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.

Indicators

Acquire unique data to improve crew health and safety and expand understanding in biology, biotechnology cell science, fluid physics, and combustion science.

Data Sources

Data sources include Space Shuttle manifests and Shuttle Program Review Change Board change requests supply data.

Data Voids

None

Results

This annual performance goal describes research that was planned for a Space Shuttle mission, designated STS-107, which was scheduled for FY 2001. Due to a series of difficulties and priority decisions not associated with the planned research, this mission has been delayed and is currently planned for late FY 2002.

Assessment

Yellow

**Annual Performance Goal 1H5**

Continue initial research on the International Space Station (ISS) by conducting 6 to 10 investigations.

**Indicators**

- Increase fundamental knowledge in biological and biomedical sciences and address critical questions in crew health and safety by conducting 6 to 10 ISS investigations.
- Acquire unique data on colloidal self assembly as an essential first step in the synthesis of new materials from colloidal particles.
- Measure the ISS acceleration environment, develop models to characterize the effects of that environment on ISS research, and disseminate those results to the ISS investigator community.

**Data Sources**

Program web sites and other sources include:

- Space Station Science Internet site, http://spaceflight.nasa.gov/station/science/experiments/index.html
- Regular reports from the ISS Research Program Office and the Space Station Increment 2 and 3 manifests provide data
- NASA also collected information from the Physics of Colloids in Space (PCS) Operational Accomplishments Report and the International Space Station Increment 2 Quick Look Report – May to June 2001. A review of the foregoing document corroborates the reports of the NASA Headquarters program manager.

**Data Voids**

None

**Results**

Initial research on the ISS is laying the ground work for safe and efficient human habitation of space while beginning to take advantage of the Space Station's unique long-duration microgravity environment for research. Research on the ISS met or exceeded expectations in FY 2001, with planned experiments successfully meeting minimum requirements. Six successful biomedical research experiments were conducted, the acceleration environment was assessed, and unique experiments were run on colloidal self-assembly.

Six research experiments conducted during research Increments 1 and 2 (during FY 2001) served to address critical questions in crew health and safety, and an additional 7 experiments were ongoing at the end of FY 2001. These experiments are enabling researchers to gather important data on radiation exposures on the Space Station, bone loss during space travel, the effects of space flight on spinal cord excitability, and psychosocial behavior on long duration missions. Specific experiments include the following:

— Dosimetric mapping

— Bonner Ball Neutron Detector

— Sub-regional assessment of bone loss in the axial skeleton in long-term space flight

— Crewmember and crew-ground interactions during ISS missions

— Effects of altered gravity on spinal cord excitability

— Phantom Torso (radiation dosimetry experiment)

Researchers are conducting an ongoing experiment on the ISS that takes advantage of microgravity to model and elucidate the processes by which particles suspended in a liquid organize themselves into regular patterns. The experiment uses a colloidal suspension of hard spheres and advanced light-scattering technologies. This research is expected to contribute to NASA's understanding of photonic materials, which will support the communications and information infrastructure of tomorrow.

Unique microgravity data on colloidal self-assembly have been collected from over 900 hours of experiment operations through a host of different state-of-the-art light scattering techniques. The PCS experiment to study how particles come together was activated on May 31, 2001. PCS completed its checkout operations on June 22, 2001. During the final 6 weeks of Increment 2, PCS completed its "Survey of Crystal Nucleation Growth." As of September 21, 2001, the principal investigators reported that "experiments performed by PCS have proceeded well with the instrumentation exceeding the team's expectations."

The ISS provides researchers with access to a unique microgravity environment in which forces of acceleration are reduced to very low levels. In addition to acceleration due to gravity, experiments on the ISS may experience acceleration due to vibrations and to changes in the spacecraft's speed or direction. In order to validate and understand experiment results, researchers require measurements of the precise level of acceleration on the ISS. NASA's biological and physical research monitors the ISS acceleration environment with the Space Acceleration Measurement System and the Microgravity Acceleration Measurement System. Both acceleration systems were flown to the ISS on STS-100, which was launched April 19, 2001. A "quick look" report, describing the acceleration environment aboard the ISS from May to June was published and distributed. Regular reports and real-time data are available at the Principal Investigator Microgravity Services web site: http://tsccrusader.grc.nasa.gov/pims/.

Assessment

**Green**

### Strategic Goal 3

Enable and establish a permanent and productive human presence in Earth orbit.

**Annual Performance Goal 1H17**

Develop new biomedical and technological capabilities to facilitate living and working in space and return to Earth. HEDS will flight test a new method for reducing the risk of kidney stone formation and develop two new evidence-based countermeasure candidates ready for evaluation.

Indicators

- Flight test countermeasure to reduce kidney stone risk.
- Develop two new evidence-based health protective countermeasure candidates ready for evaluation in an operational setting.

Data Sources

Program web sites and other sources include:

- Office of Biological and Physical Research Life Sciences task book available at http://peer1.nasaprs.com/peer_review/taskbook/taskbook.html
- Other sources of data include the ISS Increment 3 manifest (1), ISS daily reports (1), and the National Space Biomedical Research Institute Annual Report (2). Further information is also found in the following publication: "Midodrine Pre-

vents Orthostatic Intolerance Associated With Simulated Spaceflight," Ramsdell CD, Mullen TJ, Sundby GH, Rostoft S, Sheynberg N, Aljuri N, Maa M, Mukkamala, R, Sherman D, Toska K, Yelle J, Bloomfield D, Williams GH, Cohen RJ. *J Appl Physiol* 2001 Jun 90(6):2245-8.

Information on renal stone prevention and hearing loss can be found in the following publications:

- Midodrine therapy for orthostatic intolerance, "Renal and Cardio-Endocrine Responses in Humans to Simulated Microgravity," Gordon H. Williams, M.D., NSBRI-Harvard Medical School, Boston, MA – PI.
- Acoustic dampening to prevent hearing loss on the ISS, "Feedforward Active Noise Reduction Headphones for Otoacoustic Hearing Assessment of Space Station Crews," Robert J. Kline-Schoder, Creare Incorporated, Hanover, NH – PI.

Data Voids

None

Results

NASA addresses the unique physical challenges of space travel. One effect of space travel is the loss of bone mass at a rate of about 1 percent per month in weight-bearing bones. Much of this mass is excreted in the urine as calcium. The presence of elevated levels of calcium in the urine may predispose astronauts to kidney stones. As part of NASA's efforts to address this issue, the enterprise is currently flight testing potassium citrate as a countermeasure for kidney stone risk.

NASA's research identifies candidate countermeasures and develops them for evaluation and testing in space flight. Two such candidates, prepared for flight testing in FY 2001, include a medication which may help astronauts to stand immediately after returning to Earth, and an acoustic damping system to shield astronauts from noisy environments on the Space Station.

Renal stone prevention countermeasure research has been started on ISS Increment 3 and will run for several increments to obtain enough subjects.

Assessment

**Green**

**Annual Performance Goal 1H18**

Demonstrate, in ground test, at least one technology that could reduce up to 25% of life support logistics over ISS baseline and release progress report for review on the Internet.

Indicators

- Demonstrate, in ground test, technologies that could reduce up to 25% of life support logistics over ISS baseline and release report of progress for review on the Internet.
- Perform detailed calculation of life support equivalent system mass index and place online for review and comment. Equivalent system mass index is a measure of the performance of a life support system incorporating demonstrated technologies.

Data Sources

This APG was developed by the Advanced Life Support's (ALS's) Systems Modeling and Analysis team with input from NASA scientists and engineers, as well as from academia and industry. The metric and the process for its development was made available to the public on the internet. The ALS metric calculation and supporting documentation is located at http://advlifesupport.jsc.nasa.gov/.

Data Voids

None

Results

NASA conducts research on new technologies for life support systems in order to reduce the cost of human space flight while increasing safety and efficiency. In February 2001, the world's smallest high-performance mass spectrometer, contained within the Trace Gas Analyzer, was delivered to the ISS. This instrument may help astronauts detect leaks on the ISS. The instrument can detect ammonia, rocket propellant, oxygen, nitrogen, and water leaks. Dr. Ara Chutjian of NASA's Jet Propulsion Laboratory, Pasadena, California, is the principal investigator.

The mass spectrometer, about 5 centimeters long (2 inches), is part of Trace Gas Analyzer, a shoebox-sized system with software and visual readout. The whole unit weighs about 2.3 kilograms (5 pounds) and can be placed on an astronaut's chest pack, where it can easily point toward the areas under inspection. A small screen displays a graph that reports the detection of specific gases and their amounts, indicating a potential safety risk to the astronauts.

The summary metric described in the above indicators tracks progress in developing and testing technologies for reducing the mass of future life support systems. NASA's Advanced Human Support Technology program met its goal for progress in this area and posted its calculations on the web.

The calculation of the FY 2001 ALS metric demonstrates a reduction of greater than the target reduction of 25 percent for advanced life support technologies compared to the technologies baselined for the International Space Station.

Assessment

**Green**

**Annual Performance Goal 1H31**

Initiate implementation of the Bioastronautics Initiative by beginning a NASA/National Cancer Institute (NCI) collaboration and conducting a peer review of the National Space Biomedical Research Institute to assess expansion.

Indicators

- Initiate NASA/NCI collaboration to develop minimally invasive technologies and approaches for detecting and interpreting biological signatures that signal the emergence of disease.
- Initiate expansion of the teams and tasks of the National Space Biomedical Research Institute (NSBRI) for the development of countermeasures by adding approximately 15 investigations (NSBRI tasks).

Data Sources

Information is located in the NSBRI Peer Review Report, the NSBRI Annual Report, the NASA/NCI solicitation document, and at the web site http://www.nsbri.org/.

Data Voids

None

Results

NASA's Bioastronautics Initiative will strengthen development of countermeasures to the negative effects of space travel, thus facilitating cheaper and safer missions of human exploration and the eventual development of space. Initially, the initiative includes expansion of cooperative work with the National Institutes of Health and expansion of work at the NSBRI, a consortium of university researchers working to understand and develop these countermeasures. Ultimately, this work will improve health and safety for space travelers by developing protections from radiation hazards, muscle atrophy, bone loss, and other medical problems associated with long-duration space flight. NASA's Biological and Physical Research Enterprise successfully began the Bioastronautics Initiative and met the performance goal and indicators for 2001.

The enterprise and the NCI formed a partnership to jointly develop and study biomolecular sensors that have the capability to measure, analyze, and manipulate molecular processes, at scale, in the context of the living body in order to monitor human physiology and detect, diagnose, and treat cancer, disease, and radiation damage from galactic cosmic rays. Resulting technologies will hold the potential to revolutionize the practice of medicine on Earth and in space. The two organizations jointly solicited proposals in support of their new collaborative research program and received 53 proposals in response. All categories of institutions were eligible to submit proposals in response to this solicitation.

A peer review of the NSBRI was performed through the NASA Chief Scientist's Office Nov 29-Dec 1, 2000, by an external ad hoc committee. The committee recommended that the NSBRI continue for another 5 years in its efforts to develop biomedical countermeasures for long duration space flight and to expand its educational outreach. The NSBRI was asked to prepare a strategic research plan.

The NSBRI expanded from 7 to 12 constituent research academic institutions. Four new research teams with a total of 25 new investigations in these teams were added: nutrition, physical fitness and rehabilitation (3); smart medical systems (8); integrated human function (6); and neurobehavioral and psychosocial factors (8).

Assessment

**Green**

**Annual Performance Goal 1H29**

Improve the health of the NASA workforce. HEDS will develop and implement supervisor-specific training for the identification and management of stress in the work force unit. Develop and implement training on techniques of coping with stress for the individual employee and begin a robust audit program of NASA Centers' occupational health programs, completing at least six (6) to ensure quality and continuous improvement of medical care and services including medical and environmental monitoring efforts, preventive services, emergency response capability, and clinical intervention capability.

Indicators

- Developing and implement supervisor-specific training for the identification and management of stress in the work unit. Develop and implement training on techniques for coping with stress for the individual employee.
- Begin a robust audit program of NASA centers' occupational health programs, completing at least six (6) to ensure quality and continuous improvement of

medical care and services including medical and environmental monitoring efforts, preventive services, emergency response capability, and clinical intervention capability.

**Data Sources**

The Occupational Health Principal Center tracks occupational health web site (http://ohp.nasa.gov/) hits, as well as from formal reports of Center occupational health visits.

**Data Voids**

None

**Results**

The Occupational Health Principal Center developed and launched two web-based programs for stress management. One program was supervisor specific for the identification and management of stress in the work unit. A second web-based module was for employees on how to cope with stress that included an imbedded questionnaire to assess stress levels and was linked back to individual center employee assistance program. The employee module was extremely successful and in the first quarter after its release, 44,000 hits were documented to that single module, greater than any other topic to date on the occupational health web site.

The Principal Center performed assessment visits of six of the Field Centers employing a new, comprehensive assessment instrument patterned after relevant Joint Commission standards. The Principal Center assessment areas include all constituent program elements (occupational, emergency and travel medicine, environmental and radiological health, industrial hygiene, preventive/wellness services, employee assistance, workers' compensation, and physical fitness). Assessments included an entrance and exit briefing with senior center management, followed by a detailed written report within 30 days. The assessment instrument is a living document and will be refined throughout the first complete cycle of Principal Center assessments based on feedback of the process.

**Assessment**

**Green**

## Strategic Goal 4

Expand the commercial development of space.

### Annual Performance Goal 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 (CSCs), and find opportunities for space experiments.

**Indicators**

- Ensure that Commercial Centers execute ten new partnership agreements.
- Monitor the ratio of flight experiments to ground experiments.

**Data Sources**

The CSCs submit annual reports to the BPR Enterprise. New industrial partnerships, as well as many other measures of performance, are documented in these reports.

**Data Voids**

None

Results

The enterprise works with the CSCs to establish partnerships with commercial firms seeking access to space and ensures that commercial researchers are allocated access to flight opportunities and resources. Ultimately, the benefits of commercial research will include improved products and services on Earth. NASA pursues this goal by attracting new commercial partners and by finding opportunities for commercial research in space.

In FY 2001, there were at least 20 new industrial partners from a sampling of four CSCs, including: Chevron Research, Lockheed-Martin, Diversified Scientific, Inc; Virtual Drug Delivery, Inc.; Durel Corporation; Celeste Optics; Athersys, Inc.; Integrated Microsystems, Makel Engineering; Prototec, Inc.; Informed Diagnostics; and Arizona Mist, Inc. Complete listings are presented in FY 2001 annual reports. Additionally, NASA was able to successfully fly 3 CSC payloads for ISS.

Assessment

**Blue**

**Annual Performance Goal 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.

Indicators

- Review and/or implement Space Station resource pricing and intellectual property rights policies.
- Ensure Space Station resources allocated to commercial research are utilized by commercial partners to research tomorrow's products and improve industrial processes.

Data Sources

The ISS traffic model, flight selection documents, and pricing and intellectual property rights policies provided the data to measure this performance goal.

Data Voids

None

Results

NASA continues to expand its relations with the commercial research community by working through its CSCs to engage additional commercial partners and by establishing a clear policy framework. Commercial participation aboard the ISS will generate results directly relevant to improved production process, products, and services for the American economy.

ISS resource pricing and intellectual property rights policies are completed and in place. These policies can be found at http://commercial.nasa.gov.

A CSC payload flew in September 2000 BioServe/Commercial Generic Bioprocessing Apparatus (CGBA); in April 2001, on the ISS 6A mission commercial payloads flew BioServe CGBA, Center for Biophysical Sciences and Engineering/Commercial Protein Crystal Growth (CPCG); and Wisconsin Center for Space Automation and Robotics/Advanced Astroculture.

Several payloads are being prepared for flight in FY 2002 on the ISS Utilization Flight-1: Zeolite Crystal Growth, Advanced Astroculture, and Commercial Biomedical Testing Module.

With the exception of an anomaly on the BioServe CGBA mission on ISS 6A, the Commercial Space Center payloads performed well.

Assessment

**Green**

**Strategic Goal 5**

Share the experience and discovery of human space flight.

**Annual Performance Goal 1H26**

Support participation in HEDS research. In 2001 HEDS will enable at least 50 students to participate in commercial space flight and technologies research and provide 200 elementary and high school classrooms nationwide with electronic (multimedia/computer technologies) and printed materials that focus on activities in science, math and technology relating to life sciences and microgravity research and specifically written for students in grades K-12. In addition, HEDS will complete a broadly based student competition on innovative design concepts that address HEDS technological challenges and complete a customer engagement plan.

Indicators

- Enable at least 50 students to participate in commercial space flight and technologies research.
- Through the use of national teacher conferences and workshops, provide approximately 200 elementary and high school classrooms nationwide with electronic (multimedia/computer technologies) and printed materials that focus on activities in science, math and technology relating to life sciences and microgravity research and specifically written for students in grades K-12.

Data Sources

Information can be found in the Commercial Space Center report and the publication distribution counts reported by staff attending conferences.

Data Voids

None

Results

NASA produced an electronic light-tower exhibit, which traveled to five conferences across the country presenting the complete story of the development and use of the International Space Station to over 100,000 citizens. In addition, the Biological and Physical Research Enterprise exhibited at 15 educational conventions across the country supplying products to educators and 4 business conventions to inform Government and industry leaders of the commercial potential of space.

The Agency sponsored a space biology museum network that introduces 10 museum science centers to present life sciences concepts for consideration in museum exhibit planning. The enterprise conducted 6-week programs for academically gifted undergraduate students at NASA Field Centers and gave students throughout the country an opportunity to participate in hands-on investigations with space-flown seeds.

Finally, in preparation for scientific use of the ISS, students from middle and high schools in Alabama, California, Florida, and Tennessee, helped with the first long-duration experiment to be delivered to the Station. Students and teachers from 20 other states attended classes as part of the pilot education program sponsored by the Marshall Space Flight Center. NASA sponsored teacher workshops and provided curricular materials, including crystal growth experiments.

Over 50 students participated in commercial space flight and technologies research:

— Center for Biophysical Sciences and Engineering currently has 15 students working for their doctor of philosophy degrees.

— Consortium for Materials Development in Space supports 17 students in its program.

— Solidification Design Center supported 20 Bachelor of Science students, 2 Master of Science students, and a Doctor of Philosophy.

Assessment

**Green**

# Human Exploration and Development of Space

**Strategic Goal 1**

Expand the space frontier.

**Annual Performance Goal 1H1**

Complete testing and delivery for spacecraft integration of experiments for the Mars Surveyor Program 2001 missions.

Indicators

Complete testing and delivery for spacecraft integration for the Mars In-Situ Propellant Production Precursor (MIP) experiment.

Data Sources

Program web sites and other sources include:

- The FY 2000 NASA Annual Performance Report is available at http://ifmp.nasa.gov/codeb/docs/FY2000_Perf_Report2.pdf
- The FY 2000 Aeronautics and Space Report of the President is available at http://history.nasa.gov/presrep00/home.html
- The FY 2000 and current status of MIP was confirmed with the responsible project engineers at the Johnson Space Center.

Data Voids

None

Results

Development of the MIP experiment was completed on schedule in FY 2000. Because of the general replanning of Mars robotic missions following the loss of the Mars Polar Lander, actual flight of the MIP experiment could not be executed and was cancelled as reported in the FY 2000 Performance Report. The experiment equipment is currently in controlled storage at the Johnson Space Center.

Assessment

N/A

**Annual Performance Goal 1H2**

Complete initial next decade planning mission architecture studies and technology plans. Architecture studies support near-term technology investment decisions to create building blocks that may enable a range of long-term planning options for future missions of exploration.

Indicators

Complete initial next decade planning mission architecture studies.

Data Sources

Data are included in the Decadal Planning Team (DPT)/NASA Exploration Team (NEXT) meetings minutes.

FY 2001 annual review data are included in the overall annual report and individual task reports as presented to NASA and the Office of Management and Budget. Records of these efforts are maintained by the Advanced Programs Office of the Office of Space Flight at NASA Headquarters and are available on both a compact disk and an internal web site at https://infinity.msfc.nasa.gov.

Data Voids

None

Results

Throughout FY 2001, and despite NASA's cancellation of funding for the externally-competed Human Exploration and Development of Space (HEDS) Technology and Commercialization Initiative (HTCI) cooperative agreement notice, NASA continued to define potential human/robotic exploration architectures and technologies through the separately funded efforts of an interagency planning team. NEXT focused upon science-driven and technology-enabled capabilities for future applications and destinations. The completed studies have been very fruitful and will continue into FY 2002 (though at a reduced level due to budget constraints).

Assessment

**Green**

**Annual Performance Goal 1H32**

Initiate the Human Exploration and Development of Space (HEDS) Technology/ Commercialization program and establish a synergistic relationship with industry.

Indicators

Indicator is a successful response to the initial NASA Research Announcement, with a 50% cost share from industry, where appropriate.

Data Sources

Program web sites and additional sources include:

- Release of the HTCI solicitation can be confirmed at http://www.spaceref.com/news/viewpr.html?pid=3545 and http://research.hq.nasa.gov/code_m/code_m.cfm
- An overview of HTCI objectives and scope can be found at http://HTCI.nasa.gov/
- Memoranda from the Office of Space Flight to each HTCI award candidate (dated September 13, 2001) communicated the decision to not proceed with HTCI in FY 2001. Records of the award candidates and final disposition of the HTCI project are maintained by the Advanced Programs Office of the Office of Space Flight at NASA Headquarters.

Results

None

Data Voids

The HTCI, funded at a level of $20 million in FY 2001, was initiated following a 6-month program formulation involving numerous NASA Enterprises, field centers, universities, and commercial organizations. The focus of this initiative was to identify new concepts and develop new technologies to enable the future human/robotic exploration and commercial development of space.

The HTCI issued a Cooperative Agreement Notice in February 2001 (planned to be the first of an annual competitive solicitation for HEDS research and development), which yielded 152 submitted proposals, from which 43 were recommended for funding in May 2001. The resulting program would have had a total scope of $40 million over 24 months, including $12 million in cost-sharing from non-NASA sources. In the spring of 2001, the HTCI funds were frozen and in the fall of 2001, they were transferred to the ISS program.

Assessment

**Red**

**Strategic Goal 2**

Enable and establish a permanent and productive human presence in Earth orbit.

**Annual Performance Goal 1H6**

The Office of Space Flight will expedite a safety improvement program to ensure the continued safe operations of the Space Shuttle. The performance target is to have in place a Shuttle upgrade program that ensures the availability of a safe and reliable Shuttle system to support Space Station Assembly milestones and operations. The FY 2001 indicators include completion of the Checkout and Launch Control System applications software for the Orbiter Processing Facilities. All safety improvements are planned to be in place by 2005.

Indicators

Checkout and Launch Control System (CLCS) application for the Orbiter Processing Facilities is completed.

Data Sources

None

Data Voids

None

Results

This metric is no longer in concert with the proposed Space Shuttle Program Commitment Agreement and shows an inaccurate goal/indicator. A more accurate goal/indicator has been submitted that meets the intent of the GPRA requirements as follows.*

Assessment

N/A

Action Plan

None

**Annual Performance Goal 1H6***

Have in place a Space Shuttle safety investment program that ensures the availability of a safe and reliable Shuttle system for ISS assembly and operations.

Indicators

Meet the major FY 2001 Space Shuttle Safety Upgrade milestones. For purposes of this metric, major milestones are defined to be: the Preliminary Design Review dates, Critical Design Review dates, Ready for Upgrade Installation/Integration with Flight Hardware dates, and Ready for First Flight dates.

Data Sources

Shuttle Upgrade Major Milestones Summary is available at **http://sspweb.jsc.nasa.gov/upgrades/**. In addition, preliminary design, critical design, design certification, and authority to proceed reviews are available.

Data Voids

None

Results

This activity is essential to providing safe and reliable access to space. Accomplishments during FY 2001 included all testing on the High Pressure Fuel Turbopump and system development approval for the following Space Shuttle Upgrade projects: The Advanced Health Management System Phase I, External Tank Friction Stir Weld, Main Landing Gear Tire/Wheel Improvement and the Cockpit Avionics Upgrade Increment I. The APG assessment is yellow, due primarily to the fact that 4 out of 21 reviews have slipped into FY 2002. The future of the Shuttle upgrades project will be managed by both total program and annual cost performance. Current budget issues may induce deferral of some content. The future of the upgrades projects may be influenced by FY 2001 recommendations reported by the Space Flight Advisory Committee and a pending FY 2002 audit by NASA's Office of Inspector General.

Assessment

Yellow

Action Plan

The Space Shuttle upgrades will be managed by both total program and annual cost performance, technical maturity, and the magnitude of operational risk reduction.

**Annual Performance Goal 1H7**

The Office of Space Flight continues to invest in Space Shuttle operations. Investments include hardware production, ground processing, launch and landing operations, flight crew operations, training, logistics, and sustaining engineering. The annual performance goal is to achieve 8 or fewer flight anomalies per mission.

Indicators

Achieve 8 or fewer in-flight anomalies per mission.

Data Sources

The Program Requirements Control Board and Lead Center Program Management Council are the contacts for data sources.

Data Voids

None

Results

There were seven missions in FY 2001. The baselined in-flight anomalies are listed below:

| Mission | In-Flight Anomalies |
|---|---|
| STS-92 | 12 |
| STS-97 | 2 |
| STS-98 | 2 |
| STS-102 | 2 |
| STS-100 | 5 |
| STS-104 | 6 |
| STS-105 | 3 |

Compared to the average of 5.25 in-flight anomalies (IFAs) reported in the FY 2000 Performance Report, the FY 2001 average was reduced to 4.57 IFAs per mission, well within the annual performance goal threshold of 8.0. This reporting of both individual and average mission results is consistent with both past and future annual performance indicators. As reported for each mission under APG 1H30, none of these in-flight anomalies precluded accomplishment of 100 percent mission success.

The number of anomalies of a specific single mission was never intended to be an indicator of programmatic success when compared to the average for all missions, the mission-unique criticality of each anomaly, and official mission success results. The Shuttle program has been managed to this average metric for years. From a pure trend and statistical viewpoint, to have a single successful mission data point skew results for this year and its relationship to past and future year measures, would be inaccurate. The intent, and our original wording, included 'average' in this indicator definition, but was lost inadvertently.

Due to the complexity of the multitude of systems onboard the Shuttle, we occasionally experience more than 8 in-flight anomalies per mission. All these issues have been dispositioned through the program preventive and corrective action system.

Assessment

**Green**

**Annual Performance Goal 1H30**

Achieve 100% on-orbit mission success. This goal will be measured against the customer's mission objectives and the post-flight reporting of completion of mission objectives.

Indicators

- Pre-flight mission/payload objectives.
- Post-flight mission reports.

Data Sources

Data are evaluated by Shuttle customers against the success criteria in the Space Flight Operations Contract.

Contractor performance is documented by the NASA Contracting Officer's Technical Representative and by the Space Shuttle Program Manager.

Data Voids

None

Results

As determined by measurements of major mission objectives, the results for the seven missions in FY 2001 were:

| Mission | Mission Success |
|---|---|
| STS-92 | 100% |
| STS-97 | 100% |
| STS-98 | 100% |
| STS-102 | 100% |
| STS-100 | 100% |
| STS-104 | 100% |
| STS-105 | 100% |

Assessment

**Green**

**Annual Performance Goal 1H10**

Development, manufacture and test of the International Space Station (ISS) vehicle elements are phased in conjunction with the launch and on-orbit assembly schedule. The performance goal to successfully complete the majority of the planned development schedules and milestones required to support the Multi-Element Integration Testing (MEIT).

Indicators

Complete MEIT to include flight elements for assembly flights 8A through 12A. This will be measured by completion of five planned test configurations. MEIT tests perform integration testing with several launch elements to increase on-orbit confidence.

Data Sources

Data are included in the MEIT 2 Processing Team (M2PT) Schedules.

The performance goal status information is documented in weekly and monthly status reports. It is reviewed and verified weekly and monthly by the Space Station program management team. The regular status reports are available on the ISS program web sites.

Data Voids

None

Results

The Space Station program completed all of the planned MEIT Phase 2 for assembly flights 8A - 12A during FY 2001. The five-step test configuration was replanned to be accomplished in a four-step test configuration. Integrated testing for flight element 8A, including the central truss segment, Canadian Mobile Transporter base for the robot arm, and the U. S. Laboratory emulator was completed in October 2000. Integrated testing for flight elements 8A plus 9A, including the starboard truss segment, S-Band communication system and the electrical power system, was successfully completed in April 2001. Flight elements 8A, 9A, and 11A, including the port truss segment and UHF communications system, were completed in May 2001. The integrated testing for flight elements 8A, 9A, 11A, and 12A, including the second port truss segment, was completed in June 2001. The MEIT test program is valuable for demonstrating overall hardware and software compatibility and identifying any outstanding issues/ anomalies prior to launch and assembly on-orbit.

Assessment

**Green**

**Annual Performance Goal 1H11**

Deployment of the International Space Station (ISS) occurs with on-orbit assembly over several years. Successful and timely deployment is dependent on the Shuttle and other international launch vehicles, and the provision of some elements and services from international partners and participants. The performance goal is to successfully complete the majority of the ISS planned on-orbit activities such as delivery of mass to orbit and enhanced functionality.

Indicators

- Continue to expand the capabilities of the ISS through launch and delivery of 180,000 lbs. of hardware and logistics to the ISS.
- Initiate and demonstrate station-based Extravehicular Activity (EVA) capability to support up to 30 EVAs annually from the U.S. Airlock. This will be measured by completion of a minimum of 5 EVAs from the ISS Airlock.

Data Sources

The press reports and status sheets are available at: http://spaceflight.nasa.gov/station/assembly/index.html and http://spaceflight.nasa.gov/spacenews/reports/index.html. The performance goal status information is documented in weekly and monthly status reports. It is reviewed and verified weekly and monthly by the ISS program management team. The regular status reports are available on the ISS program web sites.

Data Voids

None

Results

The ISS program launched 7 Shuttle flights, plus 8 Russian Soyuz and Progress vehicle flights during FY 2001 delivering 240,000 lbs of hardware and logistics to the ISS. The program expanded the on orbit capabilities of the ISS through launch and activation of the U.S. Laboratory, the Canadian built robot arm, the Italian built logistics modules, the U.S. Airlock and the Russian docking compartment. The U.S. Airlock delivery to the ISS was accomplished in July 2001 demonstrating the capability to support Station based space walks (EVAs) without the Shuttle present. Since the EVA metric was originally defined from earlier task projections, subsequent detailed mission planning scheduled and performed only one U.S. airlock based space walk and one Russian based airlock for the 2001 fiscal year. The ISS program completed the EVA from the U.S. airlock in July 2001 and the EVA from the Service Module airlock in June 2001 as planned. ISS space walk capability was further enhanced by the completion of three EVAs from the Russian docking compartment on October 1, October 25 and November 15, 2001. With the installation of the ISS airlocks now complete, the Program will transition to use of the ISS airlocks, as well as the Shuttle Airlock for ISS assembly and maintenance space walks. Using a mixture of airlocks and suits, five ISS based sorties were completed before the end of the calendar year 2001.

Assessment

**Yellow**

Action Plan

The major elements of the EVA metric were accomplished in FY 2001 — delivery and initial use of the U.S. Airlock. Several EVAs using the U.S. Airlock are planned for FY 2002.

**Annual Performance Goal 1H12**

Operations of the ISS occur as the vehicle is being developed and assembled. The annual performance goal is to successfully complete the majority of combined ISS planned operations schedules and milestones as represented by permanent human on-orbit operations.

Indicators

Conduct permanent human on-orbit operations with estimated 8,000 crew hours dedicated to assembly, vehicle operations and payload operation.

Data Sources

The press reports and status sheets are available at: http://spaceflight.nasa.gov/station/assembly/index.html and http://spaceflight.nasa.gov/spacenews/reports/index.html. The performance status information is documented in weekly and monthly status reports. It is reviewed and verified weekly and monthly by the ISS program management team. The regular status reports are available on the ISS program web sites.

Data Voids

None

Results

The Expedition 1 crew, including one U.S. and two Russian crewmembers, was launched on October 30, 2000, initiating permanent human on-orbit operations. The Expedition 2 crew followed in March and the Expedition 3 crew started its on-orbit operations in August 2001. The ISS program dedicated 8,640 on-orbit crew hours to assembly, vehicle operations and payload operations during FY 2001 (three crewmembers for 48 weeks at 60 hours per person per week).

Assessment

**Green**

**Annual Performance Goal 1H13**

The conduct of research is an important objective of the ISS. During assembly, the ISS will add pressurized volume, experiment racks, facilities and unpressurized payload accommodations in support of research opportunities. The performance goal is to successfully complete the majority of the planned research activities in support of initiation of on-orbit research opportunities.

Indicators

- Initiate on-orbit research in the U.S. Laboratory focusing on early payload opportunities in the Human Research Facility (HRF-1) and four multipurpose EXPRESS Racks.
- Complete integration testing and Kennedy Space Center (KSC) processing for the Microgravity Sciences Glovebox (MSG), refrigerator/freezer, and Window Observational Research Facility (WORF-1) in preparation for launch on Utilization Flight-1 (UF-1) and UF-2. This will be measured by completion of schedule milestones.

Data Sources

The Payloads Office provides weekly and monthly status reports to the ISS program management for review and verification. In addition, press releases, status reports, and fact sheets are available at http://www.scipoc.msfc.nasa.gov. The regular status reports are available on the ISS program web sites.

Data Voids

None

Results

Delivery of the U.S. Laboratory Destiny in February 2001 set the stage to begin a significant level of ISS research. Outfitting of the Laboratory began with delivery of the Human Research Facility and two multipurpose payload Express Racks in March and April 2001. Two additional Express Racks were launched in August 2001. Expedition 1 included five payloads in the areas of technology development, human research, and education. Expedition 2 began a more robust program of scientific research, including 18 payloads focusing on biomedical research. The Expedition 3 payload complement includes a total of 5 research racks plus 10 new payloads and 8 ongoing payloads focusing on biomedical and microgravity research. Five additional research racks are planned for delivery to orbit during 2002, along with as many as 60 experiments begun or completed.

The MSG is currently planned to be launched on UF-2 in May 2002. The refrigerator/freezer and WORF-1 are planned for launch on the Utilization and Logistics Flight-1 in January 2003. MSG is currently at the launch site. MSG rack closeouts were completed on February 27, and the rack was installed in the Multi-Purpose Logistics Module (MPLM) on March 2. Plans remain on track for the May 2002 UF-2 launch. The refrigerator/freezer and WORF-1 are planned for delivery to the launch site in April 2002 to begin preparations for the Utilization and Logistics Flight-1 launch.

Assessment

**Green**

**Annual Performance Goal 1H14**

The International Space Station (ISS) program has undertaken a series of selected developments and support activities to enhance the robustness of the vehicle, enhance safety, and reduce reliance on capabilities contributed by Russia. The performance goal is to successfully complete no less than 85% of the planned Russian Program Assurance schedules and milestones required for the development of the Propulsion Module.

Indicators

Initiate Propulsion Module Fabrication/Assembly/Integration and Testing in preparation for launch in late FY 2002. This will be measured by completion of schedule milestones.

Data Sources

The President's Blueprint is available at http://www.whitehouse.gov/news/usbudget/blueprint/budtoc.html. An excerpt on page 155 states, "Thus, the U.S. core will be complete once the Space Station is ready to accept major international hardware elements. The cost growth is offset in part by redirecting funding from remaining U.S. elements (particularly high-risk elements including the Habitation Module, Crew Return Vehicle, and Propulsion Module)."

The performance status information is documented in weekly and monthly status reports. It is reviewed and verified weekly and monthly by the ISS program management team. The regular status reports are available on the ISS program web sites.

Data Voids

None

Results

The Propulsion Module budget was redirected by the President's Budget Blueprint to "core" program activities. Therefore, the Propulsion Module schedule milestones were not accomplished during 2001. The Propulsion Module project has subsequently been cancelled.

Assessment

N/A

**Annual Performance Goal 1H15**

Crew transportation and return for up to three crewmembers is planned to be provided by Russia throughout the life of the program. In order to further enhance ISS safety, NASA has initiated the Phase 1 development of a crew return vehicle (CRV) that could provide the U.S. crew return capability to support the emergency return of up to seven crew, the full crew complement planned for the ISS. A U.S. crew return capability is planned for deployment late in the ISS assembly sequence. The annual performance goal is to 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.

Indicators

Complete CRV Phase 1 tasks including Preliminary Design Review (PDR). This will be measured by completion of schedule milestones.

Data Sources

The President's Blueprint is available at http://www.whitehouse.gov/news/usbudget/blueprint/budtoc.html. An excerpt on page 155 states, "Thus, the U.S. core will be complete once the Space Station is ready to accept major international hardware elements. The cost growth is offset in part by redirecting funding from remaining U.S. elements (particularly high-risk elements including the Habitation Module, Crew Return Vehicle, and Propulsion Module)."

The performance status information is documented in weekly and monthly status reports. It is reviewed and verified weekly and monthly by the ISS program management team. The regular status reports are available on the ISS program web sites.

Data Voids

None

Results

The CRV budget was redirected by the President's Budget Blueprint to core program activities. Therefore, the CRV Phase 1 schedule milestones were not accomplished during 2001. The CRV project resolution will be a part of the FY 2003 budget formulation process.

Assessment

N/A

**Annual Performance Goal 1H20**

Increase the percentage of the space operations budget allocated to acquisition of communications and data services from the commercial sector to 15% in FY 2001. The space communications program will conduct tasks that enable commercialization and will minimize investment in government infrastructure for which commercial alternatives are being developed.

Indicators

Increase to 15% the space operations budget allocated to acquisition of commercial communications and data services from the 10% FY 2000 annual performance goal.

Data Sources

Data came from relevant budget submittals at the Center level. Comparison of the budget submittal and Space Operations Management Office commercialization plan measurements also provided pertinent data.

Data Voids

None

Results

Based upon review of contractual reports and the original intent of this specific metric, the Space Communication program utilized 16 percent of its Consolidated Space Operations Contract budget for commercial services. This goal was successfully achieved and will lead to further performance improvements in the future.

Assessment

**Green**

**Annual Performance Goal 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 with detailed program and project operations requirements in project service level agreements.

Indicators

Achieve at least 95 percent of planned data delivery for all space flight missions as documented in network performance metrics.

Data Sources

Data are available from the monthly Consolidated Space Operations Contract program management reviews, including operation metrics reports for space science, earth science, and human space flight facilities.

Data Voids

None

Results

Based upon review of performance metrics for each mission, the Space Communication program successfully achieved in excess of 98 percent of planned data delivery.

Assessment

**Green**

## Strategic Goal 3

Expand the commercial development of space.

There are no performance metrics for this goal in FY 2001.

## Strategic Goal 4

Share the experience and discovery of human space flight.

### Annual Performance Goal 1H26

Support participation in HEDS research. In 2001 HEDS will enable at least 50 students to participate in commercial space flight and technologies research, and provide 200 elementary and high school classrooms nationwide with electronic (multimedia/computer technologies) and printed materials that focus on activities in science, math and technology relating to life sciences and microgravity research and specifically written for students in grades K–12. In addition, HEDS will complete a broadly based student competition on innovative design concepts that address HEDS technological challenges and complete a customer engagement plan.

Indicators

- Complete a broadly based student competition on innovative design concepts that address HEDS technological challenges.
- Complete customer engagement plan.

Data Sources

NASA Means Business information is available at: http://www.tsgc.utexas.edu/nmb/2001, http://www.mba.uiuc.edu/news/archive/20010530.php, http://web.mit.edu/mars/2020vision/

HEDS-UP (University Partners) is available at: http://www.lpi.usra.edu/lpi/HEDS-UP/ and http://ehb2.gsfc.nasa.gov/edcats/

Information on the Great Moonbuggy Race is available at: http://education.msfc.nasa.gov/docs/039.htm

The status of each topic was verified by web site reviews and discussions with individual project coordinators.

Data Voids

None

Results

Three student design competitions related to planetary scientific exploration were completed. These projects highlight fresh ways to accomplish exploration objectives and build relationships between students, educators, and NASA scientists and engineers.

The HEDS-UP project provides an opportunity for university design groups to share their studies with other schools, NASA and industry representatives. Fifty-two students and 18 faculty, including undergraduate and graduate teams representing 13 universities, participated during the 2000-2001 academic year. This was the fourth annual HEDS-UP competition. Presentations at the HEDS-UP Forum in May 2001, were judged by a team of NASA and industry professionals for awards. Team reports are available via the Internet at http://www.lpi.usra.edu/lpi/HEDS-UP.

The 3rd annual NASA Means Business project sponsored by Johnson Space Center and NASA Headquarters competitively selected five university teams to develop Customer Engagement Plans for the Mars Robotic exploration program. Competing schools in 2000-2001 were the University of Illinois Urbana/Champaign, MIT, Purdue, Georgia Tech, and Colorado Boulder. In May 2001, a Customer Engagement conference was held to assess results of the competition, and to select a grand prize recipient, which was the University of Illinois. Each team also produced outreach projects, at least one per team. Final results were posted to web sites developed by each participant.

The 8th annual Great Moonbuggy Race sponsored by Marshall Space Flight Center was held in April 2001. A total of 420 high school and college students from 20 states applied their engineering skills and team spirit in designing, building, and operating human-powered vehicles along a simulated lunar terrain obstacle course. Prizes were awarded for best design and quickest traversal of the lunar course.

A HEDS Customer Engagement Plan developed in February 1999 (updated in 2000 and 2001), laid a foundation for the HEDS Education Implementation Plan document published in February 2001. In addition, the work that went into conceptualizing and developing the Customer Engagement Plan served as the foundation for creating the 7/31/01 NASA cross-cutting policy guide NPG 1090 document entitled, "Communicate, Engage, and Inspire" (a rewrite of the Communicate Knowledge factor taken from the NASA Strategic Plan).

Assessment

**Green**

# Aerospace Technology

**Strategic Goal 1**

Develop an environmentally friendly global air transportation system for the next century of unquestioned safety that improves the Nation's mobility.

**Annual Performance Goal 1R1**

Complete 75% of the conceptual designs of systems for preventing and mitigating accidents (programmatic performance indicators in appendix), and demonstrate tools for accident analysis and risk assessment; indicators include information data base and tool development, system architecture definition and evaluation, as well as ground and flight tests.

Indicators

Aerospace Focused—Aviation Safety

- Conceptual designs of safety-improvement systems is completed for all projects.
- Operational test of risk assessment aid: Demonstrate, in operational environment, tools for merging heterogeneous databases to aid causal analysis and risk assessment.
- Proficiency Standards: Identify flight crew knowledge and proficiency standards for automation.
- Integrated onboard health management system design: Define architecture for integrated onboard health management system.
- Concepts to limit fires: Develop proof-of-concept of technology to limit fuel flammability.
- Design criteria for low false alarm: Establish design criteria for reliable, low false-alarm fire detection systems.
- Synthetic vision retrofit concepts: Selection synthetic vision concepts suitable for retrofit in commercial, business, and general aviation aircraft.

Aerospace Base Research and Technology (R&T)

- Demonstrate Intelligent Life Extending Control (ILEC) for a commercial aircraft engine through hardware in the loop simulation using component damage modeling.
- 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.
- Provide alloys for engine blades and disks which are more crack resistant.
- Flight validate advanced control laws and modes for reduced pilot workload and increased safety in low visibility using integrated design tool Control Designer's Unified Interfaces (CONDUIT).
- Complete report on Phase I testing of tire dynamics mechanical properties.
- Identify and evaluate existing crew strategies for reducing errors in the management concurrent tasks.
- Downselect of ground-based remote sensor technologies for a prototype ground-based system to sense icing conditions.
- Issue an ultra-safe gear design guide for rotorcraft.

- Demonstration of strong correlation of analytic model predictions of rotorcraft crashworthiness with full-scale water/soft-soil-impact test results.
- Health and Usage Monitoring Systems (HUMS) Certification Protocols detailed for rotorcraft.
- Submit documentation of certification methodology for rotorcraft composite structures analysis/certification.
- Demonstration of "express tool" technology linkage to design technologies that reduce design-to-fabrication time by 50 percent for sophisticated rotorcraft parts and assemblies.

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

Data Voids

None

Results

During FY 2001, system design concepts that showed the greatest promise for meeting the Enterprise safety objective were selected for continued development in the areas of fire prevention, fire detection, synthetic vision, and integrated vehicle health management.

Three concepts were identified that show promise of increased flash point temperature and thus reduced flammability. The validation of low false alarm fire detection design concepts was completed through testing and analytical modeling of cargo compartment fire signatures. Monitoring for nonsmoke components of fire signatures revealed the capability to reliably screen out false alarms arising from the particulate obscuration of dust or water droplets without the accompanying build up of combustion gases.

The tactical Synthetic Vision System (SVS) is developing technologies with practical applications to eliminate low-visibility conditions as a causal factor to civil aircraft accidents, as well as to replicate the operational benefits of flight operations on a clear, sunny day regardless of the outside weather condition or time of day. Flight demonstrations of conventional media head-up and head-down tactical SVS display concepts intended for retrofit in commercial and business aircraft were conducted over a 3-week period in August-September 2001. Seven evaluation pilots representing Boeing, the Federal Aviation Administration, and three major airlines conducted 11 research flights for a total of 106 airport approaches. The concepts were evaluated in flight tests designed to evaluate pilot acceptability/usability and terrain awareness benefits. Early results indicate that pilot terrain awareness is higher when using the selected SVS display concepts compared to present-day displays. Finally, a demonstration of the selected concept for an aircraft health management system identified intentional faults that were inserted into flight data during real time simulations. The system correctly predicted the impact of the failure scenarios in time for corrective actions prior to a catastrophic failure.

In addition to the above system concepts, substantial progress was made in a number of safety-related technologies, including:

- A daisy-chain control allocation scheme, based on a second-generation neural flight control architecture applied to generic transport aircraft simulation. The daisy-chain scheme utilizes remaining operational surfaces and the propulsion system in an unconventional manner (e.g., symmetric ailerons or symmetric throttles for pitch control and rudder or differential throttles for yaw-based roll control) in order to compensate for more severe failures. Accomplishments include: reduced or eliminated need for prior knowledge of the nominal plant dynamics, explicit parameter identification, and the type/extent of failure or damage; incorporation of a Rate-Command-Attitude-Hold capability; fine-tuned handling qualities; redundant control power in the event of of actuator control loss; additional control authority in the event of actuator control saturation; and demonstrated ability to provide improved handling qualities for severe failures in a reduced flightenvelope that would otherwise result in a catastrophic event.

- The relationship between in-flight activity breaks and their efficacy as fatigue countermeasures. Research revealed that brief, hourly in-flight activity breaks physiological and subjective sleepiness for at least 15 minutes during the circadian trough, and may have continued effects for up to 25 minutes. This study is part of a fatigue research project to improve aviation safety by identifying means of increasing alertness in flight operations, and managing and mitigating the decrements in alertness and performance resulting from fatigue and circadian disruption. The results of this research were submitted to the peer-reviewed journal *Aviation, Space, and Environmental Medicine*. This research establishes an important basis for future countermeasures research and provides policy makers with scientific evidence to assist in the rule-making process.

- Existing technologies for the ground-based remote icing sensing system. Six basic technologies and two hybrid technologies were assessed. A prototype of this system, consisting of a profiling radiometer capable of providing accurate temperature profiles, the total amount of liquid water in the clouds, and a Ka-Band cloud radar to accurately define the location of the liquid water, was developed. If successful, this system will provide aircrews with information of icing conditions (including indication of hazard level) that is currently unavailable.

- Fatigue-resistant designs. Future advanced composite fuselages will consist of very thin skins adhesively bonded to reinforcing stringers. If the thin skins are designed to allow buckling motions, then fatigue failure between stringers and skin must be prevented by good design against fatigue failures. In order to provide the required design tools, many analyses of the failure modes were performed using two-dimensional (2D) and 3D finite element models (FEM). The D strain energy release rate results agreed well with the 2D plane stress finite element results, making it possible to use the simpler 2D FEM approach. Mixed-mode delamination percentages were calculated and compared to delamination fatigue characterization data. The steps of analysis were integrated with life characterization data to build the fatigue life model. To validate the final model, fatigue life predictions were then generated and compared to scale model tests. The predictions agreed well with the fatigue life data for scale specimens consisting of skin laminates bonded to laminates simulating the stiffener flange tip. Results are now ready for incorporation into the Composites Milspec-Handbook 17 used for Federal Aviation Administration certification purposes.

- Safe gears. Gear failure and drive train failure accounts for a significant portion (5 to 10 percent) of rotorcraft accidents. NASA research has now culminated in a design that will produce ultrasafe gears. Using the model, design guidelines are established to prevent catastrophic rim fracture modes. This work will enable the design of ultra-safe gears, eliminating all catastrophic failure modes for lightweight thin-rimmed aircraft gears. The model, which predicts crack propagation paths, was validated using the NASA Gear Fatigue Test Rig. However, due to manpower limitations, the development and operational testing of a risk assessment aid to provide tools for merging heterogeneous databases, will not be completed until FY 2002.

Assessment

**Yellow**

Action Plan

NASA plans to continue development of the risk assessment aid in FY 2002.

**Annual Performance Goal 1R2**

Complete one system level technology benefit assessment, one component concept selection, and one new material system; indicators include a technology benefit assessment, advanced concepts definition and selection, development of advanced materials and design methods.

Indicators

Aerospace Focused—Ultra-Efficient Engine Technology

- Select turbine flow control concept(s).
- Develop 1350°F turbomachinery disk alloy.
- Define propulsion system concept(s).
- Complete selection of the most promising simulation approach for predicting propulsion-airframe integration effects for unconventional aircraft.

Aerospace Base Research and Technology (R&T)

- Complete development of heavyweight (laboratory) energy storage (fuel) cell, electrolyze, control system.
- Investigate active control of high-frequency instabilities in combustion flows.
- Demonstration of “smart” panel technology with a wind tunnel test of a smart Unmanned Combat Air Vehicle (UCAV) with hingeless control surfaces.

**Data Sources**

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

**Data Voids**

None

**Results**

As part of the system analysis, industry and NASA design teams developed conceptual designs of advanced engines for each of the different classes of aircraft. These advanced engines were designed for a 2010 Technology Availability Date (TAD) using anticipated Ultra-Efficient Engine Technology (UEET). The analysis of these engine designs indicated that they meet or exceed both of the two opposing UEET goals of 70 percent NOx reduction relative to the 1996 International Civil Aviation Organization's low temperature oxidation NOx standard and 15 percent $CO_2$ reduction for the subsonic transports, and 8 percent $CO_2$ reduction for the supersonic business jet relative to the current technology baselines.

During the past year significant progress was made in the development of the technologies required to achieve the remarkable emission reductions cited above.

A two-stage highly loaded low-pressure turbine (LPT) aerodynamic and mechanical design was completed demonstrating flow control concept in LPT design. Flow control approaches, once demonstrated in turbine applications, will enable future turbine engine designs with significantly fewer (up to 50 percent) LPT stages and/or higher operating pressure ratios. Resultant propulsion system weight reductions will contribute to reduced fuel burn levels and therefore, reduced environmental impact of future aerospace vehicles (i.e., reduced $CO_2$ emissions). The first and second stage of the new LPT has a minimum 37-percent increased stage loading compared to the first and second stage of the current 3-stage LPT. The advanced technology concept developed in this study shows promise of eliminating one stage of an LPT for regional class applications. The removal of one of three stages of the LPT could have a significant weight reduction impact on future regional engine designs.

The "Fan Blade Trailing Edge Blowing" concept was also selected for testing, based on a Computational Fluid Dynamics simulation, from among numerous concepts submitted by NASA and industry to meet UEET (reduced $CO_2$) and Quiet Aircraft Technology (reduced noise) goals. The impact of the "Fan Blade Trailing Edge Blowing" concept is to reduce the strength of the wakes downstream of the fan blades by filling in the wakes with the Fan Blade Trailing Edge bleed flow, thereby allowing rotor/stator spacing in the fan stage to be decreased significantly. The accomplishment meets the minimum success criteria of achieving partial span filling of fan rotor wake with <1 percent mass flow with no increase in noise. Potential benefits include: an efficiency gain due to reduced fan rotor/stator spacing as the result of better wake mixing; weight savings; from overall length reduction allowed by closer fan/stator spacing; additional weight savings (blade lighter, disk lighter, and containment structure lighter); and significant potential noise reduction.

Extensive mechanical tests, as well as microstructural and fractographic evaluations, were completed on the enabling propulsion materials, revealing that the upper temperature limit for this alloy can be as high as 1350 degree F, compared to ~1200 degree F for current production alloys. Quantitative property-temperature relationships were derived to enable technology benefit studies. This turbomachinery disk material had a major impact on the U.S. turbine engine manufacturers. This alloy is recognized as state-of-the-art for both commercial and military engines of the future. Numerous engine demonstrators funded by the Department of Defense (e.g., Integrated High Performance Turbine Engine Technology) and commercial engine applications funded totally by corporate funds are currently occurring.

A rigorous validation and development activity has been performed to develop a new, accurate and robust aerodynamic design method for advanced propulsion airframe integration concepts. Current engine technology in the fleet is bypass ratio 9 engines on the Boeing 777. Ultra high bypass ratio engines are expected in the future to reduce aircraft $CO_2$ emissions 15 percent or greater. The new Three-dimensional Unstructured-grid Euler Solver/Constrained Direct Iterative Surface Curvature design tool demonstrated the ability to efficiently integrate significantly larger engines with bypass ratio 15 on a conventional jet. A revolutionary configuration, the blended wing/body (BWB), was also investigated. The BWB, but with podded nacelles, has 20 percent $CO_2$ emissions reduction compared to the same technology conventional jet. An additional 10 percent $CO_2$ emissions reduction is predicted by replacing podded nacelles with flush-mounted boundary layer ingestion nacelles.

Assessment

**Green**

**Annual Performance Goal 1R3**

Complete large-scale demonstration of a 2-5 decibel (dB) reduction in aircraft noise based on 1997 production technology, and initial assessments of concepts offering additional reduction; indicators are results of large scale component ground tests and analytical noise predictions, respectively.

Indicators

Aerospace Focused—Quiet Aircraft Technology

- Airframe and engine noise reduction concepts that individually or collectively show analytical potential for at least 3 decibel further reduction in noise levels.

Aerospace Base Research and Technology (R&T)

- Full-scale static engine validation of fan and jet noise reduction concepts including active control of fan tones, and large-scale wind tunnel validation of airframe noise reduction concepts.

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

Data Voids

None

Results

Full-scale static engine testing was conducted on a Pratt & Whitney 4098 engine to validate a combination active/passive liner to control fan blade passage frequency, improvements to the scarfed inlet, and a reduced blade count fan/stator. Tests were also conducted to separate and assess core noise. Airframe noise reduction concepts (flap edge, slat cove, flap and slat trailing edge treatments, and landing gear modifications) were validated at large scale on the Subsonic Technology Assessment Research model, a detailed 26 percent Boeing 777, which was tested in the Ames 40 x 80 ft wind tunnel. Two flight tests were conducted to validate engine system noise reduction. A chevron nozzle and other jet noise reduction concepts were validated on a Lear 25, and both jet and fan noise reduction concepts were validated on a Falcon 20. System analysis is underway to project the level of noise reduction for large transports of the specific concepts validated; however, the 2 decibel minimum was validated in flight tests for business jet-class aircraft. In order to validate the cumulative effect of these technologies in reducing aircraft noise, a computer analysis is required to integrate the results of the individual component tests.

The effort associated with the development of viable airframe and engine noise reduction concepts that individually or collectively show analytical potential for at least 3 decibel further reduction in noise levels has required more time than originally planned. This effort, including the associated integrated system analysis, will be completed in FY 2002.

Assessment

**Yellow**

Action Plan

The system analysis was completed in December 2001 and validated that the noise reduction goals were met. Likewise, the effort associated with the development of additional viable noise reduction concepts, completed in December 2001, will determine the content of the future research activities.

**Annual Performance Goal 1R4**

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; indicators include demonstrations of decision support and communication tools, as well as design databases.

Indicators

Aerospace Focused—Aviation Systems Capacity

- Comprehensive mission simulation database integrated cockpit and operating procedures for complex, low noise flight paths.

- Large scale database of noise reduction and validated design for noise capability.
- Develop and demonstrate transition airspace decision support tools for: (1) Air Traffic Control (ATC)/airline operations center and, and (2) ATC/cockpit information exchange, and conflict resolution.

Aerospace Base Research and Technology (R&T)

- Demonstrate a prototype data communications scheme for the National Airspace System.

### Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

### Data Voids

None

### Results

The tiltrotor concept was investigated as a vehicle to enable runway independent operations for commuter aircraft and thereby free up runway slots for large aircraft. The tiltrotor can land in a very small area yet fly like an aircraft in its cruise mode. However, the barriers to its acceptance are the noise generated by the aircraft at low flight speeds and assuring that noise abatement measures can be implemented while maintaining satisfactory flying qualities.

The Short Haul Civil Tiltrotor project was initiated to develop the technologies to remove these noise barriers from the tiltrotor aircraft in the NASA Advanced Supercomputing (NAS) division. The project was successfully completed in FY 2001 with:

- The development and validation of a database of low noise proprotor designs and an analysis capability suitable for the design and evaluation of efficient low-noise tiltrotors. This system was used to support the development of the safe, low-noise flight two-segment vertical and speed profiles.
- The development of a comprehensive mission simulation database of integrated cockpit and operating procedures needed the complex, low noise flight paths. The database was validated in a series of simulations with the final tiltrotor simulation experiment concentrating on safe, manual control in adverse weather. Takeoffs, landings, go-arounds, and engine failure recoveries were investigated in a congested airspace scenario based at San Francisco International Airport. Tests included flight in highly constrained airspace, landing with a 200 ft ceiling and severe cross wind, engine failures during landing and takeoff operations, and encountering a microburst in final approach. Results validated that these low noise profiles could be safely accomplished when in adverse conditions.

- Designed, fabricated and wind tunnel tested low noise proprotors - exceeded goal for proprotor source noise reduction: > 6 decibels

In addition, the Collaborative Arrival Planner (CAP) tool was developed to exchange real-time air traffic control information with Airline Operational Control (AOC) centers such that decisions made by AOCs regarding their aircraft operations could be based on the most up-to-date information possible. CAP transmits data generated in the Center-Terminal Radar Approach Control (TRACON) Automation System (CTAS) via a one-way repeater to a display in the AOC. CAP has provided the airlines with real-time air traffic situational awareness that was previously only available to the Federal Aviation Administration. This increased arrival prediction accuracy in the AOCs has enabled airlines to make better decisions regarding flight diversions, gate utilization, and push back times, etc., leading to improved efficiency of operation and financial savings. Also an enroute decision support tool for efficient, conflict-free routing was developed, and the Direct-To decision support tool underwent field testing in the Fort Worth Air Route Traffic Control Center. The Direct-To controller tool identifies aircraft that can save flight time by flying direct to a down-stream fix along its route of flight. During the test, the Direct-To ran on flat panel auxiliary display at 3 Fort Worth Center (ZFW) sectors over a 4-week period. This consisted of 136 sector-hours, 3,200 revenue flights analyzed with Direct-To, 1,100 flight plan amendments using Direct-To, and showed consistent flight savings for one DFW departure route. Ongoing analysis shows similar trends for other routes. Finally, an Air Traffic Control (ATC)/cockpit information exchange capability was developed and flight tested. Software tools that support decision making by Air Traffic Control require an ability to accurately predict future aircraft positions during flight. This trajectory prediction capability is especially important to CTAS-based tools. To perform long-range trajectory predictions, CTAS relies on the availability of aircraft state, aircraft performance, flight plan intent, and atmospheric data. The ATC/cockpit information exchange successfully demonstrated the capability to downlink aircraft state and intent information from the cockpit directly to CTAS by means of a real-time, air-to-ground datalink. Data was collected for over 1,000 United B-777 operations in Denver Center airspace (departures, arrivals, and overflights). The field evaluation demonstrated that improved predictions were possible by incorporating aircraft data directly into the Air Traffic Control system. As an example, a comparison of climb predictions at 15,000 ft to actual radar tracks showed that the direct downlink predictions reduced the peak altitude error by over 3,000 ft from the standard system. Since Federal Aviation Administration minimum allowable separation is 2,000 ft in altitude, improvements in trajectory predictions of this magnitude are likely to significantly influence Air Traffic Controller maneuver advisories.

Also demonstrated was a multi-protocol technology applicable for real-time data link between aircraft, satellite, and ground with the ability to distribute flight data with multi-level priorities among several sites. A 256-kbps transmit was achieved from a 2.180 Mbps receive to NASA DC-8 and sustained connectivity except under extreme bank/roll/heading profiles (e.g., greater than 35 degrees roll). As part of this demonstration, simultaneous applications were conducted, including Internet Protocol (web browsing/serving, email, telnet, FTP, Voice-over-IP), Aeronautical Telecommunications Network Controller Pilot Data Link Communication, Remote Buffered Network

Bus (prioritization and security features), and live video and DC-8 Digital Air Data System transmission.

Assessment

**Green**

**Strategic Goal 2**

Revolutionize air travel and the way in which air and space vehicles are designed, built, and operated.

**Annual Performance Goal 1R7**

Complete the Advanced General Aviation Transport Experiments project by validating transportation system concepts through flight test and publish design guidelines; indicators include simulations and flight tests, and published design guidelines and standards. Also establish at least one partnership agreement on Small Aircraft Transportation System program.

Indicators

Aerospace Focused—Small Aircraft Transportation System (SATS)

- Partnership agreement signed by NASA and at least one state government and one industry member.
- Joint Sponsored Research Agreement signed with Virginia Space Grant Consortium partners to develop a SATSLab comprised of aircraft, airports, and airspace for validation of SATS vehicle and infrastructure features and capabilities.

Aerospace Base Research and Technology (R&T)

- Complete the development rig test of the hot section foil bearing for a representative general aviation engine.
- Simulate and flight test validated Advanced General Aviation Transport Experiments (AGATE) system concepts.
- Publish design guidelines; system standards; certification bases and methods.
- Completed systems analysis of the benefits of Short Takeoff and Landing (STOL) & Extremely Short Takeoff and Landing (ESTOL) vehicles to the small aircraft transportation system.

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council Meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

Data Voids

None

Results

Four SATSLab teams; Virginia, Florida/Southeast, North Carolina/Upper Great Plains, and Maryland have been established and work has begun on the development of the systems engineering documents and planning of the FY 2005 flight demonstrations. Each team includes representatives from the state aviation/transportation departments, private industry, general aviation user groups, and academia/other non-profit organizations.

In addition, the AGATE project successfully flight tested the Highways in the Sky (HITS) operating capability, Datalink Infrastructure Facility (DIF) system, and simplified flight controls. With the completion of the HITS tests and subsequent demonstration at the Oshkosh air show, the hardware/software development activities planned for the AGATE program were completed. However, publishing of the associated design guidelines, system standards, certification bases and methods has not occurred. This effort is underway and will be completed in FY 2002.

Assessment

**Yellow**

Action Plan

The design guidelines, system standards, certification bases, and methods have been completed and published in December 2001.

Prototype journal foil air bearings for the engine core shaft of an oil-free version of the Williams International EJ-22 engine were tested at NASA Glenn Research Center. The bearings were tested through the range of high-speed, sustained-load, and elevated-temperature conditions representative of the engine core operating environment. Oil-free foil air bearing technology eliminates the need for oil lubrication systems required by rolling element bearings in gas turbine engines. Oil-free technology reduces engine weight by 15 percent, operates at very high speeds yielding power density improvements of 20 percent, reduces engine maintenance costs by 50 percent, and, with NASA coating technology, operates at high-temperatures up to 1200 deg. F. Analysis has shown that for a 50-passenger regional jet, oil-free technology can reduce direct operating cost by 8 percent.

**Annual Performance Goal 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 systems capability build to technology readiness level 3: indicators include computer testbed demonstrations, real-time remote access of data, new design methods and an intelligent synthesis environment proof-of-concept system.

Indicators

Aerospace Focused—High Performance Computing and Communications (HPCC)

- Develop software tools to reduce parallelization time from months to one week while maintaining 50% application performance compared with manual parallelization.
- Develop tools to benchmark testbed performance in computing capability, database manipulation, and scheduling to evaluate alternate scheduling strategies and choose optimal approaches to reduce variability and improve predictability of turnaround time.
- Develop automated quality of service data collection tool capable of measuring 2 service classes and scalable to at least 5 nodes.

- 3 relevant application codes parallelized; 3 data analysis codes parallelized; documented evaluation of parallelization tools.
- 3X performance in an aerospace application through the integration of networking enhancements into application codes.
- 3 applications interoperating on multiple Quality-of-Service (QoS) enabled networks; 50 Mbps (aggregate internal) multicast; gigabit performance between 2 NASA sites; 2 applications utilizing enhanced hybrid networking.
- Improvement in aerospace applications: Complete combustor and compressor simulation in 3 hours each; high-fidelity space transportation vehicle analysis in 1 week and optimization enabled; S&C database generation for aerospace vehicles within 1 week; demonstration of improvements in 4 NASA-sponsored design events.
- Assess initial HPCC technology capabilities and customer impacts.
- Demonstrate a near-term, state-of-the-art intelligent synthesis environment (ISE), user interface and infrastructure.
- Demonstrate life-cycle simulation and ISE capabilities as specified by the prototype test applications (i.e., legacy engineering and analysis tools.)
- Validate three prototype test applications.
- Demonstrate ISE prototype measurement and assessment techniques.

Aerospace Base Research and Technology (R&T)

- Develop software tools for design of advanced computing systems.
- Acquire and incorporate new large-scale computing systems and demonstrate seamless operations with heterogeneous distributed computing environment.
- Demonstrate remote connectivity to high data-rate instruments and distributed real-time access to instrument data.
- Demonstrate an environment for aerospace hardware design that includes: remote connectivity and access to flight simulation data, computational simulation data and archival databases.
- Demonstrate prototype cross-fidelity aerospace design system.
- Establish experimental and analytical methodology for composite stringer pull-off failure prediction.
- Figures of merit from static wind tunnel or CFD results developed and assessed for use in predictions of uncommanded transonic lateral motions due to Abrupt Wing Stall.
- Conduct turbulence modeling workshop to provide direction for turbulence modeling research to increase design confidence in flight regimes dominated by flow separation.
- Conduct assessment of OAT program element impacts on goals of three pillars.

### Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council Meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

### Data Voids

None

### Results

In FY 2001, NASA developed several new design tools, accomplished four demonstrations of advances in computation and communications, and completed the intelligent syntheses environment proof-of-concept systems capability build to technology readiness level 3.

- The new design tools include remote connectivity, quality of service data collection, seamless operations of heterogeneous distributed computing environment, stringer pull-off failure prediction, and Abrupt Wing Stall predictions.
- Demonstrating the capability to integrate piloted simulation in a design event. Flight simulation data was presented visually and textually to vehicle designers in real-time as the simulation took place. Pilot feedback on flight handling and landing characteristics was provided orally in real time with summarization available at the end of each simulation shift. The aggregation of this data was used by designers to determine appropriate vehicle redesigns to generate improved control, handling, and performance characteristics. Vehicle redesigns were generated in, at most, 4 hours due to automated parametric geometry manipulation capabilities. A complete low-speed aerodynamic database was generated using CFD in 1 1/2 days, formatted and transferred to the simulator where the pilots compared changes in a total of 3 days time. The previous time span for accomplishing this ability to develop a geometry, an aero-database and a piloted simulation, with goals generated from previous simulations, ran into the months. This activity also demonstrated the ability to provide a collaborative environment that enabled realtime dissemination of flight simulator data and information among different design groups at remote sites.
- Developed an automated Quality-of-Service data collection tool capable of measuring 2 service classes and scalable to at least 5 nodes. PCMon, a general networking monitoring and measurement tool, was developed to enable detailed analysis of individual traffic flows. PCMon is a Quality-of-Service and multicast data collection tool designed to determine the effectiveness of assigning preferential treatment to specified traffic flows. PCMon was successfully demonstrated to measure traffic in a WAN environment. The PCMon capability is currently deployed at four locations.
- Developed the middleware services required for building large-scale, dynamically constructed problem solving environments from distributed, heterogeneous resources. The Information Power Grid (IPG) provides a uniform view of resources,

including a large-scale computing node, thus allowing the computational scientist a greater range of resources available to solve problems. IPG provides the same access interface for all of the resources noted above. Second, large scale distributed systems can be built by using the IPG mechanisms for locating and aggregating components, thus providing the potential of solving larger problems than otherwise possible. Demonstrated a 60-million grid-point aerospace design and simulation problem using 108 processors of the Large-Scale IPG computing node Lomax. Prior to this milestone, simulation of a much smaller aerospace problem (9 million grid points running on a maximum of 32 processors available on IPG) was possible.

- Established experimental and analytical methodology for composite stringer pulloff failure prediction. Future advanced composite fuselages will consist of very thin skins adhesively bonded to reinforcing stringers. If the thin skins are designed to allow buckling motions, then fatigue failure between stringers and skin must be prevented by good design. In order to develop these tools, many failure mode analyses were performed using two-dimensional (2D) and 3D finite element models. The 3D strain energy release rate results agreed with the 2D plane stress finite element results, making it possible to use the simpler 2D finite element mode (FEM) approach. Mixed-mode delamination percentages were calculated and compared to delamination fatigue characterization data. The steps of analysis were integrated with life characterization data to build the fatigue life model. To validate the final model, fatigue life predictions were then generated and compared to scale model tests. The predictions agreed with the fatigue life data for scale specimens consisting of skin laminates bonded to laminates simulating the stiffener flange tip. Results are now ready for incorporation into the Composites Milspec-Handbook 17 used for Federal Aviation Administration certification purposes.
- Abrupt Wing Stall (AWS) is a sudden stall of an aircraft involving a significant loss of lift. For high performance aircraft, it occurs over relatively small changes in angle of attack and/or sideslip. AWS results in large rolling motions and loss of tactical advantage of the aircraft when stall occurs asymmetrically. Uncommanded lateral motion has occurred on a variety of tactical aircraft, including the F-18E, YF-16, YF-17, F-15, and EA-6B. Historically, flight tests were the only reliable source to find solutions to mitigate the AWS phenomena. For example, the F/A-18E was forced to rely on flight tests to resolve the AWS phenomena. This task took ~1.5 years of developmental flight-testing and evaluation of over 100 different configurations and over 500 flights and cost millions of dollars before a solution was found, based on NASA-developed porous membrane technology. The AWS project is developing the wind-tunnel testing methodologies to identify uncommanded lateral motions during the early aircraft design stages. This ensures that any potential problem is eliminated before flight testing is started. NASA is working jointly with the U.S. Navy and the U.S. Air Force on the wind tunnel testing at NASA Langley. In FY 2001, this project developed validated figures of merit for the identification of AWS and is continuing to complete the development of design guidelines and procedures for the prevention of the AWS phenomena and other uncommanded transonic lateral motions for future high performance aircraft.
- Develop agent-based framework for interoperability of high-fidelity design and analysis tools, including aerodynamics, structures, heat transfer, thermal protection

systems, and optimization. These high-fidelity tools and framework were applied to 4 vehicle designs for 2nd Generation and Office of Space Flight, including crew return vehicle, shuttle redesign with return-to-launch-site maneuver, sharp vehicle configurations, and Mars sample return vehicle. Multi-source data was combined to determine viable approach for safe return of Mars sample return vehicle in the event of loss of Shuttle orbiter during reentry. The testing demonstrated 1-week turnaround of vehicle analysis with optimization, enabling rapid generation of analysis database for several optimized Crew Transfer Vehicle (CTV) designs.

- Completed Script Controller database generation for Harrier in ground effect in 1 week. This simulation used 952 dedicated Origin 2000 and 3000 processors. And computed 35 solutions and used interpolation to produce database with 2501 solutions. During the past year, 80 Reynolds-averaged Navier-Stokes solutions have been computed that demonstrated the capability to compute very complex flows about complex geometries in about 2.5 days – a 17 times speedup over the 1999 baseline.
- Finally, the proof-of-concept synthesis environment for distributed, collaborative design consisting of near-term, state-of-the-art environments, with user interface and infrastructure, were developed for three large-scale applications. The deliverables included a near-term, state-of-the-art environment, user interface and infrastructure, validated on 3 prototype test applications (legacy engineering and analysis tools), and prototype measurement and assessment techniques. All of the applications have made substantial positive impacts on customer operations, with reductions in time and improvements in quality.

Assessment

Green

**Annual Performance Goal 1R9**

Demonstrate two new concepts in flight and identify five new concepts for further examination; indicators include vehicle development, flight tests and systems analyses of advanced concepts.

Indicators

Aerospace Base Research and Technology (R&T)

- Demonstrate solar-powered remotely-piloted aircraft suitable for science missions to an altitude of 100,000 feet.
- Complete development of a pulse detonated engine inlet.
- Complete final validation and testing of an integrated blended-wing-body (BWB) low-speed flight research vehicle in preparation for flight in 2002.
- Complete inlet test for Pulse Detonation Engine application.
- Complete second flight of Hyper-X (X-43) at Mach 7.
- Complete flight testing of Hyper-X (X-43) at Mach 10.
- Complete an integrated blended-wing-body (BWB) low-speed flight research vehicle prepared and delivered for final validation and testing.
- Identify advanced vehicle concepts for further research.

- Demonstrate robust taxi capability with contingency planning for an autonomous vehicle.
- Complete 60% of planned experiments on the F-15B testbed aircraft.

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data is reported at the Lead Center Program Management Council Meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

Data Voids

None

Results

On August 14, 2001, in a record-breaking flight, the Helios aircraft established the absolute altitude record for no-rocket powered aircraft by sustaining level flight above 96,500 ft for over 40 minutes. The previous record was 85,068 ft established by the SR-71. Data gathered during the mission will be used to validate and improve models for the continued development of solar powered aircraft technology. The Helios flew to 96,863 ft during its record setting flight. AeroVironment produced an analysis of the vehicle to illustrate the potential for higher flight. The flight date was delayed for safety review and takeoff time was delayed due to clouds over the airfield. The analysis indicates that flying on a longer day and starting earlier with an optimized flight path would result in flight above 100,000 ft. The maximum projected flight could be above 101,000 ft. The flight demonstrated NASA's capability to exceed the Helios customer requirements.

The X-43A is designed to be the first scramjet-powered vehicle, capable of attaining speeds as high as Mach 10. The X-43A mission (June 2, 2001), first in a series of three, was lost moments after the X-43A and its launch vehicle were released from the wing of the NASA B-52 carrier aircraft. Following launch vehicle ignition, the combined launch vehicle and X-43A experienced structural failure, deviated from its flight path and was deliberately terminated. A Mishap Investigation Board (MIB) was immediately formed and is conducting a thorough review of the failure. The MIB findings will be addressed prior to scheduling the next X-43 flight.

The Dryden Flight Research Center software for the Unmanned Combat Air Vehicle (UCAV) taxi test was delivered to the contractor and is awaiting the commencement of the taxi tests.

The Revolutionary Concepts Program (REVCON) has been terminated. There were no selections made for concepts to proceed into Phase II and the funding of the "Quick Start" activities has been halted.

The following experiments were successfully flown on the F-15B testbed aircraft: demonstration of Boeing advanced door seal in five flights at subsonic and supersonic Mach numbers Joint Strike Fighter (flight envelope); a flight to evaluate a new skin friction gage prototype designed by Virginia Tech; a Flow Angle Probe (patent pending); and an Aerostructures Test Wing.

Upon release of the X-43 MIB results, the actions required to accomplish the next X-43 flight will be assessed and planned. However, it is not anticipated that this flight will occur prior to the beginning of FY 2003.

There will be no further effort expended with the achievement of the 100,000 ft flight of the Helios. The August 14 flight data combined with analysis showed that under the proper conditions, the system has the potential to achieve the 100,000 ft goal. The Helios effort will now be focused on the accomplishment of the long duration flights (at lower altitudes).

The UCAV taxi tests were scheduled to be completed in FY 2002.

Complete actions required to close out the REVCON program.

Assessment

**Red**

## Strategic Goal 3

Achieve the full potential of space for all human endeavor through affordable space transportation.

### Annual Performance Goal 1R10

Complete assembly of the third X-34 test vehicle, demonstrate 75% of supporting technology developments (programmatic performance indicators in appendix), and complete competitive solicitations for expanded 2nd generation reusable launch vehicle efforts; indicators for supporting technology development include both flight tests and ground tests.

Indicators

Aerospace Focused—X-33

- A performance indicator for the X-33 is not possible until the liquid hydrogen tank delamination investigation and program impact assessment are complete.

Aerospace Focused—X-34

- Complete the third X-34 (A-3) vehicle assembly.

Aerospace Focused—Future-X

- The integrated vehicle health monitoring system flight experiment is delivered for installation in the X-34.

Aerospace Focused—2nd Generation Reusable Launch Vehicle (RLV) Focused

- Award multiple industry contracts for Systems Engineering and Requirements Definition, Reusable Launch Vehicle (RLV) Competition and Risk Reduction, and NASA Unique Systems program elements.

Aerospace Base Research and Technology (R&T)

- Complete assessment and preliminary design of Pulse Detonation Engine-based hybrid cycle and combined-cycle propulsion systems.
- Complete Phase 1 modifications of the Numerical Propulsion Simulation System to allow analysis of a rocket and a rocket-based combined-cycle propulsion system.
- Identify protocols and test methods needed for accelerated testing of space transportation vehicle materials.
- Extrude near-net thin walled sections of Russian alloy 1441 for aerospace applications.
- Complete RLV focused composite cryogenic tank and structures technologies.
- Combined Cycle Engine System selected for first Flight Demonstrator.
- Combined Cycle Flowpath Definition and Testing completed for First Flight Demonstrator.

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council Meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

Data Voids

None

Results

As a result of concern over potential safety hazards due to the lack of redundancy in vehicle control systems, it was determined that the X-34 program should be restructured. A replanning activity undertaken to address the concerns resulted in a determination that a significant amount of additional funding is required to meet the revised flight plans. It was decided that the X-34 risk reduction activities should be required to compete for the additional funding under the planned Space Launch Initiative (SLI) NASA Research Announcement on the same basis as other proposed research activities. The X-34 was not selected and a decision to terminate the project was made in March 2001.

The Space Launch Initiative is a comprehensive research and development effort that provides technology developments that dramatically increase the safety, reliability and affordability of space transportation systems. Last year, NASA awarded contracts valued at $767 million to 22 contractors, including large and small companies, to allow maximum competition. The money will be used to develop concepts and the technologies needed to pioneer this extraordinary effort, which is expected to make the vehicle at least 10 times safer and crew survivability 100 times greater, all at one-tenth the cost of today's space launch systems.

In addition to the SLI efforts, the following technologies were demonstrated:

- Completed Phase 1 modifications of the Numerical Propulsion Simulation System to allow analysis of a rocket and a rocket-based combined cycle propulsion system. The rocket-based combined cycle capability provides a simulation capability not previously known to exist (coupled primary flow path and feed system). Close coupling demonstrated greatly reduced analysis time. The coupling of the two different systems inside one simulation, the addition of thermal (heat transfer) modeling capabilities, and the expansion of the fuel properties representation into temperature and combustion regions were not previously modeled.

- Extruded near-net thin walled sections of Russian alloy 1441 for aerospace applications. Four segments of an integrally-stiffened thin-walled aluminum-lithium (Al-Li) alloy 1441 extrusion were successfully fabricated by the All-Russian Institute of Aviation Materials. These extrusion segments are approximately 80 inches long by 38 inches wide with 1.5-in tall T-stiffeners spaced approximately 4.75 inch apart. The wall thickness of the extrusion is approximately 0.070 inch, which is representative of aircraft fuselage skin thickness. Conventional Al and Al-Li alloy extrusions typically have more than twice this wall thickness to help prevent warpage during the extrusion process. These thin-walled, near-net-shape extrusions have minimal warpage and require much smaller amounts of machining to produce a finished fuselage panel than a thick-walled extrusion. The Al-Li extrusions have the potential to lower the cost and weight of structure for aircraft and launch vehicles.

Assessment

**Red**

**Annual Performance Goal 1R11**

Commence X-37 vehicle assembly, and complete one Pathfinder flight experiment.

Indicators

Aerospace Focused—Future-X

- Commence X-37 vehicle assembly.
- Propulsive Small Expendable Deployer System (ProSEDS) evaluation completed.
- Flight of Hall Effect Thruster experiment

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program Management Council Meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

Data Voids

None

Results

The assembly of the X-37 vehicle has started. However, technical difficulties have delayed the X-37 project and have resulted in increased expenditures. As a result, the program completed as part of the Space Launch Initiative (SLI) NASA Research Announcement for additional funding, but was not selected for funding. This, coupled with the limited Shuttle availability, has made the accomplishment of the planned orbital missions unrealistic. NASA remains committed to the original cooperative agreement and is in negotiations with the contractor to define the future X-37 technical and programmatic content and schedule. The ProSEDS experiment will demonstrate the technologies that can be used for low-cost orbit transfer and power generation. The experiment is a secondary payload that will be launched on a Delta II rocket. The development of the PROSEDS experiments was completed based on a planned August 2001 launch. However, due to other priorities, the U.S. Air Force remanifested this experiment as part of a June 2002 launch.

Assessment

**Yellow**

Action Plan

ProSEDS is now planned for a June 2002 launch. The evaluation of the ProSEDS mission data will be completed following the mission. Complete X-37 negotiations.

## Strategic Goal 4

Enable, and as appropriate provide, on a national basis, world-class aerospace R&D services, including facilities and expertise.

### Annual Performance Goal 1R12

Continue the solicitation of customer feedback on the services, facilities and expertise provided by the Aerospace Technology Enterprise; indicators include two customer survey instruments utilized by the Aerospace Technology Enterprise, along with documented cases of new technologies transferred to industry and other government agencies.

Indicators

Triennial Customer Survey

- Complete the Triennial Customer Satisfaction survey, and maintain a "highly satisfied" rating from 35 percent of Enterprise customers.

Facility Utilization Survey

- Achieve a facility utilization customer satisfaction rating of 95 percent at "5" or better, and 80 percent at "8" or better, based on exit interviews.

Technology Transfer

- Transfer at least twelve new technologies and processes to industry during the fiscal year.

Data Sources

The data used to substantiate actual performance originated at contractor or government facilities and include test reports, computer analyses, simulations, system analyses, and actual flight test data. NASA and industry experts evaluated and verified the results of the tests, simulations, studies, and other data sources. The data are validated by NASA center project and program personnel assigned management responsibility for the task accomplishment. The data are reported at the Lead Center Program

Management Council Meetings and to NASA Headquarters. The results of the studies are documented in technical presentations, as well as NASA and contractor publications.

**Data Voids**

None

**Results**

Three NASA Research Centers (Ames, Glenn, and Langley) conduct customer satisfaction interviews at selected wind tunnels and motion-based simulators to both gauge and improve their services to users. For the nearly 80 surveys received during FY 2001, over 80 percent of the respondents were "highly satisfied" (8 points or higher rating on a 10 point scale) with the service and 100 percent responded as "satisfied" (5 or higher rating).

It is essential that NASA technology be actively transferred to end-users. During FY 2001, the user community acknowledged the transfer of the following new technologies and processes:

- Modifications to aerospace design codes that enable efficient use of parallel and distributed computer systems.
- CART3D (Three-Dimensional Cartesian Simulation System for Complex Geometrics) software package for conceptual and preliminary design of aerospace vehicle.
- PEGASUS 5 software for joining overset grids.
- Highway in the Sky system.
- Deployment of native multicast protocols within their network domains (e.g., Sprint, Qwest, Level3).
- Multicast capabilities in Cisco Systems, Inc., routers.
- Numerical Propulsion System Simulation (NPSS) V1 software (GE, Pratt & Whitney, etc.).
- Aerospace Technology Low NOx combustor utilized in the PW4000 TALON II engine.
- Spatial Auditory Display Technology (speech communications) to BreakAway Technologies.
- Ultra Safe Gear design/guide.
- Composite Stringer Fatigue Life Model.
- Highly accurate, computer analysis for predicting Helicopter crash damage in soil and water, and designing safer, more crashworthy aircraft.
- Web-based, highly efficient design tools for designing lighter, stronger aircraft structures.
- New lightweights graphite composite material for fire resistant engine compartment doors that can withstand a 2,000 deg F flame for 15 minutes.
- New fly-neighborly, low-noise approach paths to reduce rotocraft noise by 10 decibels.

Assessment

**Green**

**Annual Performance Goal 1R13**

Continue the implementation of current education outreach plans, and establish new plans for all new program activities initiated in FY 01; indicators include examples of educational outreach activities for current plans and the planning documentation for new programs.

Indicators

Education Outreach

- Implementation examples from current education outreach plans.
- Documented plans for all new program activities initiated in FY 2001.

Data Sources

Data are obtained from individual program plans and educational products. The data are verified by Center project and program personnel and validated by the Office of Aerospace Technology educational specialist.

Data Voids

None

Results

Education plans were developed for all new programs, including the Small Aircraft Transportation Systems Program, the Quiet Aircraft Technology Program, the 2nd Generation RLV Program, and the Intelligent Systems Program.

Examples of the education products defined in existing programs include: the production of a jet engine demonstration model for Explorer Scouts and other student programs; “The Plane Game” for grades 2-6; development of educational videos and CD’s; development of programs broadcast on NASA’s distance-learning television programs NASA Connect, The “Why” Files, Destination Tomorrow; and supporting teacher and student workshops at various NASA Centers.

Assessment

**Green**

# *NASA's Crosscutting Processes*

# Manage Strategically

**Strategic Goal**

Ensure that the Agency meets its responsibilities safely and effectively, as it allocates its resources to support NASA's strategic, implementation, and performance plans.

**Annual Performance Goal 1MS1**

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 five performance indicators in this area.

Indicators

- Per President Clinton's direction, under the Federal Worker 2000 Presidential Initiative, reduce the overall occurrence of injuries (due to occupational injury or illness) by 3% per year from the FY 97 baseline to 1.15 occurrences per 100 workers.
- Award of construction contract(s) for all identified critical facilities safety requirements as specified in the Agency Annual Construction Program.
- Award/modification of all planned contracts for physical security upgrades to NASA's Minimum Essential Infrastructure (MEI) defined in the NASA Critical Infrastructure Plan.
- Reduced incidences of environmental mishaps or non-compliance from the FY 2000 baseline year by 5%.
- Exceeding the FY 99 baseline for NASA's aggregate safety Performance Evaluation Profile (PEP).

Data Sources

Data were obtained from the NASA Environmental Tracking System (NETS).

Definitions for "spills" and "non-compliances" were based on existing regulatory program requirements that were evaluated at NASA's Centers by external regulators. All Centers concurred on the definitions through the NASA Environmental Management Board and they were coded into the NETS automated data collection system to eliminate data discrepancies.

Data Voids

None

Results

NASA reduced the overall occurrence of occupational injuries and illness to a rate of 0.31 occurrences per 100 workers, well below the goal of 1.15 occurrences per 100 workers.

NASA awarded 60 of the 64 construction contracts planned for FY 2001 to improve safety requirements in critical facilities (94 percent). (Although this rate is below the 100 percent rate implied by the performance indicator [written as "…all identified critical facilities safety requirements…"], including the word "all" was a typographical error.)

In FY 2001, NASA established new physical security standards for Minimum Essential Infrastructure facilities, conducted appropriate risk assessments and evaluated those facilities against the new standards, and completed upgrades within existing resource availability. In addition, NASA requested funding for major upgrades, as an over-guideline submission to the Office of Management and Budget to begin in FY 2003.

In FY 2000, there were 218 incidents of environmental mishaps or noncompliance (119 noncompliance incidents and 99 spill incidents). In FY 2001, there were 218 incidents

(139 noncompliance incidents and 79 spill incidents). While the overall environmental mishap incident level remained unchanged, NASA reduced spill incidents by 20 percent. In addition, all 139 noncompliance incidents were resolved (98 were resolved within 30 days), and no fines were levied on the Agency.

NASA has conducted the Performance Evaluation Profile Occupational Safety and Health Survey for civil service personnel since FY 1999. In FY 1999, the Agency aggregate profile scores for the survey were 3.4 for employees and 3.4 for managers. In FY 2001, the Agency civil service scores were 3.9 for employees and 4.0 for managers. The Level 4 rating is indicative of programs that have a planned strategy for continuous improvement and a goal of achieving an outstanding safety and health program. Clearly, NASA's FY 2001 scores indicate that NASA is approaching this standard.

Assessment

**Yellow**

Action Plan

Significant progress was made in meeting the remaining two performance indicators, and no special action is planned to accomplish this goal since one of the metrics was dropped for FY 2002, and the wording was revised for FY 2002.

**Annual Performance Goal 1MS2**

Continue to take advantage of opportunities for improved contract management by maintaining a high proportion of Performance Based Contracts (PBCs), and maintain significant contractor involvement in NASA programs for small businesses, minority institutions, and minority and women owned businesses by meeting 2 out of 2 performance indicators in this area.

Indicators

- Maintaining PBC obligations at 80% of funds available for PBCs (funds available exclude grants, cooperative agreements, actions under $100,000, Small Business Innovation Research [SBIR], Small Business Technology Transfer [STTR], Federally Funded Research and Development Centers [FFRDCs], intragovernmental agreements and contracts with foreign governments or international organizations).
- Achieving at least an 8% goal for annual funding to small disadvantaged businesses (includes funding for prime and subcontracts awarded to programs supporting small disadvantaged businesses, historically Black Colleges and Universities, and other minority institutions, and women-owned small businesses.)

Data Sources

Indicators of progress, and ultimately success in meeting the performance-based contracts' annual performance goals, are collected from the Financial and Contractual Status system, which contains acquisition data submitted by all NASA Centers.

Data on annual funding to small disadvantaged businesses comes from the Agency-wide Procurement Management System for direct contract award. NASA's large prime contractors furnish data on their small business awards using the subcontracting Report for Individual Contracts (SF 294) and the Summary Subcontract Report (SF 295). Agency reports are forwarded to the General Services Administration Federal Procurement Data Center for consolidation into a government-wide report for the President and Congress.

NASA Headquarters periodically examines a sampling of contracts to determine whether they meet the definition of a performance-based contract.

Contracting officers and small business specialists at NASA Centers analyze and verify data on direct contract awards using the SF 294. Contract analysts in the Headquarters Office of Procurement review and verify data submitted by large businesses that are required to submit the SF 295. The Small Business Advisor in the Office of Small and Disadvantaged Business Utilization consolidates the small business data to ensure its accuracy before publication. Headquarters oversight personnel also perform data checks during periodic Procurement Management Surveys at NASA Centers, and the Small Business Administration and the Defense Contract Management Agency conduct data reviews on subcontract reporting at large business locations as required.

Data Voids

None

Results

In FY 2001, NASA continued to take advantage of opportunities to maintain a high proportion of PBCs and to increase awards of contract dollars to small disadvantaged businesses. NASA obligated 86 percent of funds available against PBC contracts during FY 2001 against a goal of 80 percent.

NASA awarded better than 19 percent of its total contract dollars to small disadvantaged businesses—the highest level ever achieved by the Agency. NASA Centers contributed 8 percent of the 19 percent even though prime contract awards by the Centers constitute only 14 percent of the total NASA dollars awarded.

Assessment

**Blue**

**Annual Performance Goal 1MS3**

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.

Indicators

- Cost at least 75% of the resources authority available to cost during the fiscal year.
- Completing installation of the Budget and Core Accounting Integrated financial Management System at NASA's remaining field locations.
- Maintain a diverse NASA workforce wherever women, minorities, and persons with disabilities are represented at levels equal to or greater than their FY99 levels, with a target of increasing representation of minorities by at least one % per year, women by at least one % per year, and persons with disabilities by at least .5% per year.
- Increasing training opportunities in technology-based learning by 10%.
- Increasing by 20% employee use of technology-based learning opportunities.
- Using FY 01 budgeted funds for awarding construction contracts toward reducing the Agency's estimated $1.4B facilities revitalization needs.
- Implement 60% of the identified Environmental Compliance and Restoration (ECR) projects to reduce and manage the Agency's $1.1B future unfunded environmental liability.

**Data Sources**

Workforce diversity representation data are from the NASA Consolidated Agency Personnel and Payroll System (as of September 8, 2001).

The ECR program data comes from the NASA Financial and Contractual Status system.

Technology-based learning is training that provides technology-based resources and occurs at the individual's workstation or at a nearby remote site. Examples of learning technologies include audio tapes, cable broadcasts, computer-based training (text only), interactive TV, teleconferencing, and interactive video training. Examples of methods and means for distributing learning technologies include cable TV, videocassette, CD-ROM, extranet, Internet, e-mail, and simulators. Each NASA Center tracks and reports on the number of courses, programs, offerings, events, and attendees to determine how many training opportunities occurred and to measure the instances of employee utilization. For example, if 25 employees attend a satellite seminar, that would be counted as one training opportunity and 25 instances of employee usage.

The NASA Financial and Contractual Status system is maintained and validated by NASA's Office of the Chief Financial Officer.

Records for technology-based training opportunities and usage are maintained by the NASA Centers to permit review of performance.

**Data Voids**

None

**Results**

In FY 2001, NASA leveraged limited resources and moved toward the Agency's objective of optimizing investment strategies and systems to align resources with customer requirements. NASA increased representation of minorities and women enabling the Agency to utilize the abilities of historically under-represented talent. Alternative training methods enhanced employee performance by enabling more employees to participate in training at less cost to NASA. With an investment of $20.9 million for environmental remediation, NASA reduced potential environmental liabilities by $82 million.

NASA costed 82 percent of the resources authority available during FY 2001.

As the following chart indicates, although the Agency did not achieve the precise workforce diversity levels as planned, representation of minorities and women in the NASA workforce increased significantly.

| | FY 1999 In Percent | FY 2000 In Percent | |
|---|---|---|---|
| Minorities | 21.1 | 21.8 | (+.07) |
| Women | 32.1 | 32.8 | (+.07) |
| Individuals w/ Targeted Disabilities | 1.1 | 0.9 | (-.02) |

There was a 127 percent increase in training opportunities over the FY 1999 baseline against a goal of 10 percent. This excellent result reflects NASA's commitment to seek out and offer to employees nontraditional forms of training that meet individual needs without requiring time away from the workplace and travel costs. Technology-based training meets these criteria, as well as allowing employees to learn at their own pace. (NOTE: The performance indicator inadvertently failed to indicate that FY 2001 performance would be measured against the FY 1999 baseline.)

There was a 122 percent increase in the use of technology-based learning opportunities over the FY 1999 baseline against a goal of 20 percent. NASA employees are clearly making use of new technology-based training opportunities at a rate that far exceeds expectations. This is due in part to NASA's funding of several new training initiatives, including satellite delivery of Linkage series management seminars and development of new training modules for the Agency's web-based training system.

At the start of FY 2001, NASA had an estimated $1.4 billion of facilities revitalization needs and a facility revitalization rate of 136 years. By the end of FY 2001, NASA reduced the facilities revitalization rate to 96 years, exceeding the goal of 100 years. As of August 31, 2001, NASA obligated $20.9 million (63 percent) of the identified ECR projects impacting the Agency's environmental liability. Through the ECR program, NASA stresses cleaning up all contaminated sites as rapidly as possible to protect human health and the environment. The obligation rate of 63 percent resulted in an overall decrease of the Agency's estimated environmental liability from $1,021 million to $939 million during FY 2001.

Assessment

**Green**

**Annual Performance Goal 1MS4**

Improve information technology (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.

Indicators

- 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 the FY98 baseline.
- (b) Enhance IT security through reduction of system vulnerabilities across all NASA Centers and through emphasis on IT security awareness training for all NASA personnel.

Data Sources

Data sources for IT service delivery and costs included customer surveys and certification by managers and contractors.

Data sources for IT security enhancement and IT training include scanning systems to detect vulnerabilities, Site for Online Learning and Resources web training certification records, NASA Center chief information officers, training managers, and IT security managers' assessments.

IT service delivery and cost data are validated by the chief information officers of NASA's Centers, the staff of the NASA Automated Data Processing Consolidation Center, the NASA Integrated Services Network project office staff, and the Outsourcing Desktop Initiative for NASA (ODIN) project office staff. The data are reviewed by several layers of management, and metrics are made available to customers being served.

IT system vulnerability reduction data and IT training data are validated and verified by the NASA deputy chief information officer for IT security, the NASA Centers chief information officers, the NASA security manager, the NASA Centers IT security managers, the NASA Centers training managers, the NASA Integrated Services Digital Network project office staff, and the ODIN project office staff. Their verification process consists of reviews by several layers of management and making metrics available to customers being served.

Data Voids

None

Results

In FY 2001, NASA improved IT infrastructure service delivery and customer ratings while cutting costs. At the same time, the Agency enhanced IT security by identifying and reducing system vulnerabilities and emphasizing security awareness training for civil service employees at all levels.

NASA improved Agency-wide IT support and customer satisfaction ratings while holding or reducing costs per resource unit to the FY 1998 baseline:

- On a scale of 1.00 (Very Unsatisfied) to 5.0 (Extremely Satisfied) with 3.0 to 3.9 being Satisfied, customer satisfaction ratings throughout the fiscal year for Agency-wide IT infrastructure services were consistently at or above 4.0 against a goal of maintaining ratings between 3.0 and 3.9.
- Unit costs/costs per general purpose seat, administrative computing resource unit costs, and data transmission costs were consistently below the FY 1998 baseline throughout the fiscal year.

All NASA Centers detected and reduced system vulnerabilities. IT security awareness training was made available to all NASA civil service employees, civil service managers, and civil service system administrators. By the end of FY 2001, 93 percent of all civil service employees had completed the training; 100 percent of all civil service managers had completed the training; and 98 percent of all civil service system administrators had completed the training. In addition, 98 percent of all IT Security Plans for Special Management Attention Systems were completed.

Assessment

**Green**

# Generate Knowledge

**Strategic Goal**

Extend the boundaries of knowledge of science and engineering, capture new knowledge in useful and transferable media, and share new knowledge with customers.

**Annual Performance Goal 1G1**

NASA will obtain at least 7 letters of advice through the Enterprise advisory committees.

Indicators

At least seven letters of advice will be received from the Space Science Enterprise (ESE), and the Office of Life and Microgravity Sciences and Application/Human Exploration and Development of Space (OLMSA/HEDS) Enterprises' Federal Advisory Committee Act (FACA) chartered advisory committees.

Data Sources

The sources of data are the executive secretaries for each of these committees. The executive secretaries are NASA civil servants, while the committee is composed of external advisors. The letters of recommendation are part of the official record of the Agency and are maintained by the executive secretaries and their support staff in each of the Enterprises.

Data Voids

None

Results

The FACA-chartered advisory committees for each of the Science Enterprises met as scheduled and submitted letters of advice to each of the Offices. The Biological and Physical Research Advisory Committee met on February 15-16, 2001, and June 14-15, 2001, and produced two formal recommendations as a result of each meeting. The Space Sciences Advisory Committee met on November 1-3, 2000, March 20-22, 2001, and July 25-27, 2001, and submitted three letters. The Earth System Science and Applications Advisory Committee met on December 5-6, 2000, and May 22-23, 2001, and submitted two letters. In total, seven letters were received.

Assessment

**Green**

**Annual Performance Goal 1G2**

The Space Science Enterprise (SSE), the Earth Science Enterprise (ESE), and the Office of Life and Microgravity Sciences and Application/Human Exploration and Development of Space (OLMSA/HEDS) will develop and/or release updated enterprise strategic plans. NASA will meet at least 2 out of 3 of the indicators for this annual performance goal.

Indicators

- In FY01, the Space Science Enterprise and the Earth Science Enterprise will release new enterprise strategic plans.
- OLMSA will release its new strategic plan as the Biological and Physical Research Enterprise.
- HEDS will release an updated enterprise strategic plan.

Data Sources

The sources of information are the five NASA Enterprises. The Enterprises maintain updated web sites about their programs and policies.

Data Voids

None

Results

This annual performance goal was not fully met. Only one of the three indicators was met. ESE and SSE both released new strategic plans in December 2000. The Earth Science plan is available at: http://www.earth.nasa.gov/visions/stratplan/index.html. The Space Science plan is at: http://spacescience.nasa.gov/admin/pubs/strategy/2000/index.html. The new strategic plan for the BPR Enterprise was delayed due to restructuring of the International Space Science research program. The new release date was December 2001. The HEDS strategic plan was released in November 2001, and is available at: http://www.hq.nasa.gov/osf/heds/HEDS_WEB/main.html.

Assessment

Yellow

Action Plan

BPR will finalize its strategic plan to support the FY 2004 budget submissions.

**Annual Performance Goal 1G3**

The Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS will use competitive merit review wherever possible to select performers for science and basic technology research. NASA will meet at least 2 out of 3 of the indicators for this annual performance goal.

Indicators

- NASA will use Announcements of Opportunity (AOs), NASA Research Announcements (NRAs), and Cooperative Agreement Notice solicitations to award 80 percent or more of science and basic research funds via merit competition in the Enterprises and Functional offices that fund scientific research.
- NASA will meet the level of funding requested by the investigators in their proposals 80% of the time.
- NASA will increase the number of investigators funded over the 1999 baseline.

Data Sources

The data sources for the indicators for which we could compile data are the research enterprises, specifically SSE, ESE, and BPR. The Enterprise program analysts compile the data from the actual budgets. Program analysts, working with the enterprise policy analysts, also provide the counts for principal investigators. These counts are, in some cases, performed by hand, in addition to a computerized count, to ensure the validity of the data. For FY 1999 numbers, the number of investigators is, in some cases, extrapolated, because this was not a metric used that year and the exact count does not exist.

Data Voids

None

Results

In FY 2000, 84 percent of the research and analysis funds of the three Enterprises listed above were peer reviewed. In FY 2001, 83 percent were peer reviewed. This indicates that, overall, the Agency has consistently awarded, through competitive merit review, more than 80 percent of the targeted funds for scientific research. The funds that are not peer reviewed are awarded to specific research needed by the Agency to successfully complete its missions.

| Enterprise | Peer Reviewed Research in Dollars | Total Research in Dollars | Percentage |
|---|---|---|---|
| Earth Science | 278,599,685 | 373,455,000 | 76 |
| Biological and Physical Research | 50,800,000 | 53,900,000 | 94 |
| Space Science | 180,400,000 | 189,500,000 | 95 |
| **Total** | **509,799,685** | **616,855,000** | **83** |

NOTE: These figures exclude earmarks, internal taxes, and minority university earmarked funds.

The second indicator identified at the time this document was prepared in FY 2000 could not be met because the Agency does not maintain such records, making it impossible to gather the data.

The third indicator was designed to inquire whether the Agency increased the number of scientists funded from FY 1999 to FY 2001. This indicator was met. The original intent was to use these data in determining whether NASA is reaching out to more potential researchers and as a result, more proposals are received by the Agency. Unfortunately, the way the indicator was worded will not provide the data needed to meet the original intent of the query. After analysis by the Office of the Chief Scientist, it was determined that an increase in the number of researchers from one year to another is not a direct indication of the health of the programs. Many factors need to be considered, including allocated budgets and grant sizes. In other words, the Agency can award more grants of smaller value to increase the number of investigators, but these smaller grants are not necessarily of better quality than fewer grants of larger size.

| Enterprise | 1999 Principal Investigators | 2001 Principal Investigators |
|---|---|---|
| Earth Science | 1123 | 1245 |
| Biological and Physical Research | 877 | 975* |
| Space Science | 1184 | 1315 |
| **Total** | **3184** | **3535** |

*This is an estimate. The final count has not been validated.

Assessment

Green

**Annual Performance Goal 1G4**

The Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS will achieve all 3 indicators results [*sic*] of disseminating results of their research to a diverse population of users via the internet and publications.

Indicators

- Research programs of the Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS, taken together, will account for 5 percent of the 150 “most important stories” in the annual review by *Science News*.
- The three enterprises will achieve their individual indicators in education and public outreach and publication of research progress.
- The three enterprises will maintain and periodically update publicly accessible web sites for active missions.

Data Sources

For the first indicator, the data source is the *Science News* periodical. The data for the second indicator are gathered by the program managers for education and outreach for each of the Enterprises and are reported as part of the Enterprise's individual performance reports. The ESE reported on APG 1Y18, and the SSE reported on APG 1S9. The data for the third indicator are available from the NASA web site.

Data Voids

None

Results

The first indicator was successfully completed and exceeded all expectations: for the stories reported in Calendar Year 2000, the last year for which NASA has this metric, the Space Science Enterprise accounted for over 4 percent of worldwide discoveries, and the Earth Science Enterprise accounted for 3 percent of the discoveries, bringing the NASA total to 8 percent, the best overall performance since 1996. This survey of stories is performed by *Science News* in the second quarter of the fiscal year (in this case FY 2001) and it reflects the accomplishments of the calendar year.

The second indicator was successfully completed. The SSE, ESE, and HEDS Enterprise, in conjunction with the BPR Enterprise, rated "green" overall in the completion of their education and outreach indicators.

The third indicator was successfully completed. The SSE web site, http://spacescience.nasa.gov/missions/index.htm, is a central location with links to all active missions, as well as upcoming missions. The ESE web site, http://www.earth.nasa.gov/missions/index.html, is the location with links to all active and future missions funded by the Enterprise. BPR has no active dedicated missions; however, it has payloads flying on the ISS. The web site http://spaceresearch.nasa.gov/news.html maintains an updated account of the results of those experiments, as well as other news of general interest.

Assessment

**Green**

**Annual Performance Goal 1G5**

The Space Science Enterprise, the Earth Science Enterprise, and OLMSA/HEDS will make science data obtained widely accessible as soon as possible after receipt and will maintain these data in open archives. NASA will meet the two indicators for this annual performance goal.

Indicators

- The Space Science Enterprise, and the Earth Science Enterprise, will achieve their specific individual indicators for ensuring mission data maintenance and access.
- OLMSA will continue the archival of their life sciences research publications.

Data Sources

The data for the first indicator are gathered by the program managers for each of the Enterprises and are reported as part of the Enterprises' individual performance reports. ESE reported on 1Y2. SSE does not have one specific indicator for data distribution. SSE makes public the data gathered from its missions as soon as validation occurs. The following goals, related to data generation, can be utilized to ensure that the broad Agency goal of data availability is met: 1S2, 1S4, 1S5, 1S4, 1S10, 1S11.

The data source for the second indicator is the manager of the Bioastronautics Division in the Office of Biological and Physical Research. Spaceline is an on-line, searchable bibliographic database. Spaceline provides a "one-stop shop" for all space life sciences publications, including the new area of astrobiology. The archive is available at http://spaceline.usuhs.mil/.

Data Voids

None

Results

The first indicator was exceeded by the ESE and SSE. ESE developed an annual performance goal to measure specifically its data generation and distribution. This goal was comprised of six indicators, all of which were met and five of which were exceeded. The indicators range from faster data availability, to increasing the amount of archived data for user availability, and increasing user satisfaction. ESE exceeded expectations in performance.

SSE does not have one specific indicator for data distribution. Its performance report is appropriately organized according to the fundamental objectives of the Enterprise. SSE makes public the data gathered from its missions as soon as validation occurs to determine the success of the missions that were planned for FY 2001. Overall, the Enerprise reported five annual performance goals related to data generation. It met all of the goals and exceeded expectations in four.

The Office of Biological and Physical Research, previously named the Office of Life and Microgravity Sciences and Applications, continued to archive its life sciences research publications. Spaceline is a valuable resource for the research community and is of extreme importance, because the life sciences community relies on published literature as the primary source of knowledge for its disciplines.

Assessment

**Green**

**Annual Performance Goal 1G6**

NASA will work with other federal agencies and U.S. industry to complement and support our activities. This will be measured by renewing Memoranda of Understanding (MOUs) and Memoranda of Agreement (MOAs) with our partners and opening new areas of cooperation by way of the same mechanisms.

Indicators

- Establish and implement at least one MOU or MOA with U.S. Federal agencies and industry for appropriate partnerships in research areas of shared interest.
- Renew at least one MOU or MOA with U.S. Federal agencies and industry for the areas that will continue to be productive.

Data Sources

MOU and other interagency agreements are maintained for the official record by each of the strategic enterprises.

Data Voids

None

Results

SSE, ESE, and BPR Enterprises worked with other Federal agencies to leverage resources, design better missions, and reduce duplication of efforts. NASA's unique resources are utilized by a variety of agencies to accomplish common processes. An interagency agreement to support the National Oceanographic Partnership Program was signed by NASA in October 2000. In December 2000, NASA signed an MOU with the Federal Emergency Management Agency for joint work in disaster mitigation and preparedness activities, including mapping of potential earthquake sites.

During FY 2001, NASA signed the following MOUs with the:

- United States Uniformed Health Services (USUHS) to renew the support for the Spaceline Archive Management System – December 13, 2000.
- USUHS to renew the support for Funds for Applied Biomedical Research and Dr. Victor Schneider as the bioastronautics lead scientist – December 14, 2000.
- U.S. Department of Agriculture to formalize and foster new areas of cooperation – January 2001.
- National Institute on Deafness and Other Communication Disorders to renew the support for the Studies of Sensory-Motor Functions Responsive to Gravity in Genetically Altered Model Systems – January 25, 2001.
- Lawrence Berkeley Laboratory to renew the support for the Training and Basic Research Related to Health Effects of Exposure to High-Energy Ionized Particles in Extended Missions – January 30, 2001.
- National Institute on Neurological Disorders and Stroke to renew the support for the Application of Robotics to Neuromuscular Adaptations – April 24, 2001.
- National Cancer Institute to renew the support for Mechanisms of Genomic Instability from Exposure of Mammalian Cells to High Linear Energy Transfer Ionizing Radiation – May 22, 2001.
- National Science Foundation to renew the support for the Human Frontier Program – August 16, 2001.
- National Library of Medicine to renew the support for the Spaceline bibliographic archive – August 21, 2001.

Assessment

**Blue**

**Annual Performance Goal 1G7**

Pursue new, mutually beneficial cooperative activities in aeronautics and space with other nations. This will be measured by the initiation of new Letters of Agreement (LOAs) and Memoranda of Understanding (MOUs) with our partners.

Indicators

Establish and implement at least one LOA or MOU for appropriate partnerships with foreign space agencies for cooperative activities.

Data Sources

The Office of External Relations maintains the MOA and LOA with international partners, and specifically by the divisions that support each of the Strategic Enterprises.

The records may be retrieved by contacting the Enterprises or the Office of External Relations.

| | |
|---|---|
| Data Voids | None |
| Results | NASA continues to strategically leverage resources with its international partners. Expectations in this area have more than exceeded NASA's intended goal. In FY 2001, NASA concluded over 80 international agreements with 30 countries and international organizations in support of the Enterprises, for space education activities, or to establish a framework for subsequent arrangements. These include MOUs for significant international cooperation and LOAs for visiting researchers, data analysis, ground-based projects, and other cooperation with foreign entities.<br><br>It must be noted that very few MOUs for significant international cooperation are concluded each fiscal year. However, numerous LOAs are required to complete nominal operations for the Agency. This was not fully understood by the Generate Knowlege steward when the Agency Performance Plan was formulated and this is why the indicator appears to be so low. |
| Assessment | **Blue** |

# Communicate Knowledge

**Strategic Goal**

Ensure that information derived from NASA's research efforts is distributed in a useful, timely, and reliable manner.

**Annual Performance Goal 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 annual performance goal.

Indicators

- Support no less than 800 portable exhibit loans and send portable exhibits to a minimum of 175-targeted events per year. Some of the NASA Centers have Internet sites that provide information about their exhibit loan programs. By the end of FY 2001, all of the Centers will have this on-line resource.
- Track public attendance and participation in NASA's Fine Arts Program increasing viewership by 10 percent per year of NASA art and by reaching 40 states by the end of FY 2001.
- Increase the baseline for live satellite interview programs to no less than 15 live shots per month (on average), by facilitating astronauts, program managers and other Agency officials for live satellite interviews via NASA Television.
- Increase the NASA-sponsored, funded, and/or generated report documents for the scientific community and public by approximately 14,000.
- Increase the nontraditional NASA-sponsored scientific and technical information through the NASA Image eXchange (NIX) digital image database to more than 550,000 in FY 2001.
- Produce 10 new historical publications chronicling and placing NASA's activities and achievements in perspective for the American public.

Data Sources

Indicators were evaluated using input from monthly field center reports, contractor reports, the NASA Television executive producer, and the History Office. Monthly reports from field centers included participant information to determine how many people attended each event. Burrelle's Information Services provided the field center reports and commercially acquired video monitoring report. Contractors collected the metric data as part of the contract report. Measurement is based on actual count of publications.

Data Voids

None

Results

NASA exceeded the first indicator by providing over 1,933 exhibits and supporting over 675 events in FY 2001. NASA's message to nontraditional audiences at state fairs, conventions, and other venues brings our message to a public that may otherwise be uninformed about or uninterested in NASA programs. Seeing NASA's message close to home or in a form not necessarily aimed at science and research makes the message more relevant to people's lives. In addition, NASA uses exhibits for educational purposes in schools, encouraging students to study math and science. All NASA Centers now have on-line resources providing information about their exhibit loan programs.

The NASA Art Program has increased its exposure to the public through stories in newspapers such as the *Wall Street Journal*, and on networks like CNN and Fox News. Taking NASA art to more locations, through programs such as Artrain USA has in-

creased public attendance and participation in the NASA Art Program.
NASA exceeded the plan for an average of 15 live shots per month by achieving an average of 48 live shots per month.

The NASA Center for AeroSpace Information, on behalf of the NASA Scientific and Technical Information (STI) Program, added approximately 16,133 citations of NASA reports or documents to the NASA STI Database.

For FY 2001, NIX now accesses approximately 441,600 images held in 17 databases and another 2,640,000 images on NASA web pages. NIX added access to these web images through the web link entitled "Additional NASA Imagery." NIX added the web access to address the change in NASA Centers' policy away from formal databases.

NASA exceeded the indicator for 10 publications in FY 2001 by producing the following 14 publications:

Beattie, Donald A. *Taking Science to the Moon: Lunar Experiments and the Apollo Program* (Johns Hopkins University Press, July 2001, New Series in NASA History).
Benson, Charles D., and William Barnaby Faherty. *Gateway to the Moon: Building the Kennedy Space Center Launch Complex* (University Press of Florida, March 2001). Paperback reprint of first half of *Moonport: A History of Apollo Launch Facilities and Operations* (NASA SP-4204, 1978).
Benson, Charles D., and William Barnaby Faherty. *Moon Launch! A History of the Saturn-Apollo Launch Operations* (University Press of Florida, March 2001). Paperback reprint of first half of *Moonport: A History of Apollo Launch Facilities and Operations* (NASA SP-4204, 1978).
Burrows, William E. *The Infinite Journey: Eyewitness Accounts of NASA and the Age of Space*. (Discovery Publishing, October 2000).
Gorn, Michael H. *Expanding the Envelope: Flight Research at NACA and NASA* (University Press of Kentucky, August 2001).
Kraemer, Robert S. *Beyond the Moon: A Golden Age of Planetary Exploration*,1971-1978. (Smithsonian Institution Press, October 2000).
Launius, Roger D., John M. Logsdon, and Robert W. Smith. Editors. *Reconsidering Sputnik: Forty Years Since the Soviet Satellite*. (Harwood Academic Publishers, October 2000).
Logsdon, John M, General Editor. *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume V, Exploring the Cosmos* (NASA SP-
Orloff, Richard G, Compiler. *Apollo by the Numbers: A Statistical Reference*. (NASA SP-2000-4029, December 2000).
Portree, David S.F. *Humans to Mars: Fifty Years of Mission Planning, 1950-2000* (NASA SP-2001-4520, February 2001).
Rumerman, Judy A., and Stephen E. Garber, Compilers. *A Chronology of Space Shuttle Flights, 1981-2000*. (NASA HHR-70, October 2000).
Swanson, Glen E, Compiler. *Mercury, Gemini, and Apollo Mission Transcripts: The Complete Air-to-Ground Transmissions* (NASA SP-2000-4601, December 2000).
Tucker, Tom. *The Eclipse Project* (NASA SP-2000-4523, December 2000).
Waltman, Gene L. *Black Magic and Gremlins*: *Analog Flight Simulations at NASA's Flight Research Center*. (NASA SP-2000-4520, November 2000).
2001-4407, August 2001).

Assessment

**Green**

**Annual Performance Goal 1CK2**

Inform, provide status, enthuse, and explain results, relevance and benefits of NASA's programs by meeting 2 of the 3 indicators for this annual performance goal.

Indicators

- Provide the public with quick service by assisting 98 % of customers who use the Scientific and Technical Information and the NASA Image eXchange (NIX) Help Desks within a specific turnaround period of 3 days.
- Make the NASA Web pages as accessible to the public as possible. The goal is to increase the number of searched pages by 5 percent per year.
- Increase the capacity of NASA's Home Page to meet public demand. The goal is to continue to provide for a 5% per year increase in download demand. 834,700 web pages were downloaded in 1999.

Data Sources

Through monthly reports, the NASA Center for AeroSpace Information provided data on the number of customer requests and turnaround time. External customer evaluation surveys track the effectiveness and timeliness of the Help Desk response to NASA's customers. Additional sources include the Office of Public Affairs webmaster, contract reports, and automatic built-in statistics-gathering software.

Data Voids

None

Results

Approximately 10,578 customers used the Scientific and Technical Information and NIX Help Desks in 2001; a 98 percent rating would equate to providing quick service to 10,366 customers. The program continues to make tremendous strides in providing customer service to the public as evidenced by receiving a 99 percent rating from its 10,527 help desk customers. The NASA Center for AeroSpace Information handles the NASA STI and NIX Help Desks for NASA.

The number of pages downloaded from the NASA home page web site (http://www.nasa.gov) in FY 2001 was 72.5 million, approximately 8 percent lower than in FY 2000 (79.1 million). This figure does not necessarily indicate a decreased interest in the NASA web site. During the same period, the number of visits to the NASA web site increased slightly: 39.9 million in FY 2001, up from 37.7 million in FY 2000. The most likely explanation is that the stability of the web site's structure has allowed people to become very familiar with it. They are likely to have bookmarked the particular web pages in which they are interested, decreasing the number of pages they look through on each visit. Because of the uncertainty associated with interpreting this metric, in FY 2002, the Office of Public Affairs will be changing to a new metric, tracking the number of news stories posted to the NASA home page.

Assessment

**Green**

**Annual Performance Goal 1CK3**

Ensure consistent, high-quality, external communication by meeting 2 of the 3 indicators for this annual performance goal.

Indicators

- Increase new opportunities to transfer technology developed at NASA to private industry to 20,100. Opportunities will be made available to the public through the NASA Technology Tracking System (TechTracS) database and will be accessible through the Internet.
- Produce two industry-specific editions of the *Aerospace Technology Innovation* publication in FY 2001.
- Provide publications that will communicate technologies available for commercial use or that have already been commercialized. Print subscriber/distribution metrics are: *Aerospace Technology Innovation*, (12,500), *Spinoff* (51,000), and *Tech Briefs* (210,000).

Data Sources

Data were obtained from the NASA TechTracS database, Field Center commercial technology offices, NASA HQ, and the Office of Aerospace Technology. *Aerospace Technology Innovation* produced the following two industry-specific publications in FY 2001: *NASA Seeks Partnership with Sensors Industry* (May/June 2001) and *NASA's Role in Education* (July/August 2001). The *Aerospace Technology Innovation* mailing list and electronic subscription request file, recorded inventory and distribution requests, and monitored web site hits also provided data.

Data Voids

None

Results

In FY 2001, 19,635 viable NASA technologies were made available to the public through the NASA TechTracS database. The goal of 20,100 was not achieved this fiscal year due the fact that NASA Centers remove technologies from the NASA TechTracS database each year that are outdated or can no longer be supported with NASA expertise. From year to year the number of removals will be greater or less than the new technologies which are added.

All publications were developed, printed, and distributed on a production schedule. Electronic readership in FY 2001, as measured by hits on-line: *Aerospace Technology Innovation*: 68,046 on-line hits, *Spinoff*: 178,352 on-line hits, and NASA *Tech Briefs*: 1,075,356 on-line hits. In addition to the on-line distribution, paper copies were published as follows: *Aerospace Technology Innovation*: 13,458 copies (bimonthly average) and *Spinoff*: 55,000 copies. Each subscription for NASA *Tech Briefs* represents 1.3 additional readership distributions, bringing the total distribution to 474,103. NASA published a special edition on *NASA Seeks Partnership with Sensors Industry* in May/June 2001 and *NASA's Role in Education* in July/August 2001. These special editions of *Aerospace Technology Innovation* were published to promote NASA sensor technologies to targeted industry groups, and to promote NASA educational initiatives in aerospace, the solar system, and planet Earth.

Assessment

**Green**

**Annual Performance Goal 1CK4**

Use NASA's ability to support meeting the Nation's education goals by meeting 3 of the 4 indicators for this annual performance goal.

Indicators

- With increased level of funding provided in the FY 2001 President's Budget, NASA will be able to maintain education program level with participation involvement of approximately 3 million teachers, faculty, and students in the education community.
- Ensure that the NASA Education Program is meeting customer's needs by maintaining an "excellence" rating of at least 4.3 on a 5.0 scale, as rated by those customers.
- After a 2-year flat budget, the increased funding provided in the FY 2001 President's Budget will enable NASA to increase the number of sites that offer pre-college Science, Engineering, Mathematics, and Aeronautics Academy curriculum by 2 from FY 1999.
- Produce 3 refereed papers or book chapters for each $100,000 of research funding provided through the Minority University Research & Education Program.

Data Sources

Program participant information and excellence ratings were collected by way of the NASA Education Program Framework and Evaluation System. Results of a solicitation, peer review, and selection process provided data, as well as on-line "Uniform Outcomes" data collection from the principal investigators for all research awards.

Data are collected from Agency-wide, Enterprise, and Center education programs through an on-line data collection system. This system captures participant demographic information, as well as excellence ratings of specific program features.

Site visits to the institutions, reverse site visits by the principal investigators, and written annual reports also provide pertinent data.

For more information on the Nation's educational goals see http://www.negp.gov/page3.htm.

Data Voids

None

Results

Eight national education goals have been defined by the governors and the Congress to improve learning and teaching in the Nation's education system. The goals help provide a national framework for education reform and promote systematic changes needed to ensure equitable educational opportunities and high levels of educational achievement for all students.

Goal 1 - Ready to learn

Goal 2 - School completion

Goal 3 - Teacher education and professional development

Goal 5 - Mathematics and science

Goal 6 - Adult literacy and lifelong learning

Goal 7 - Safe, disciplined, and alcohol– and drug–free schools

Goal 8 - Parental participation

The NASA Education Program exceeded its FY 2001 performance indicators by providing 3.6 million teachers, faculty, and students access to and full participation in education programs, while receiving an excellence customer service rating of 4.62 for the year.

The Minority Universities Research and Education Program received 10 proposals that offered pre-college curriculums in FY 2001. This program targets school districts with large numbers of students who have been traditionally under-represented in science, engineering, mathematics, and technology. A NASA research announcement was issued, soliciting proposals from eligible minority institutions. Proposals were peer reviewed by an external panel that made selection recommendations to the selection official. Five were recommended and selected. This increased the number of sites that offer pre-college science, engineering, mathematics, and aeronautics academy curriculum by five, exceeding the FY 2001 indicator.

A total of $24,031,680 was awarded for research in the Minority Universities Research and Education Program. One phase of the program is to increase the scholarly productivity of the research program and the principal investigators, as well as their research productivity. A data call is made each year to each research principal investigator to submit data on leveraged funds, student support, degrees awarded, refereed papers and/or book chapters, and presentations and panels. Within this awarded amount, a total of 798 refereed paper and/or book chapters were produced. That is, 3.32 refereed papers were produced for each $100,000 funding, thereby meeting this FY 2001 indicator for the Minority Universities Research and Education Program.

Assessment

**Green**

# Provide Aerospace Products and Capabilities

**Strategic Goal 1**

Enable NASA's Strategic Enterprises and their Centers to deliver products and services more effectively and efficiently while extending the technology, research, and science benefits broadly to the public and commercial sectors.

**Annual Performance Goal 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.

Indicators

Development schedule and cost data are drawn from NASA budget documentation for major programs and projects to calculate the average performance measures.

Data Sources

The cost and schedule baseline documents are produced by the Enterprises and submitted to the Office of the Chief Financial Officer for validation.

The current projected cost and schedule is compared to the baseline estimate of cost and schedule for development and upgrade of major scientific facilities and capital assets (Spacecraft and Technology Programs). Data from each Enterprise are provided to the Office of the Chief Financial Officer for Agency roll-up.

Data Voids

None

Results

This metric reflects the effectiveness and efficiency with which NASA's Strategic Enterprises and Centers serve their customers by honoring cost and schedule commitments. The life cycle costs for the development and upgrade of major scientific facilities and capital assets were an average of 118 percent of cost estimates. The life cycle schedules for the development and upgrade of major scientific facilities and capital assets were an average of 123 percent of schedule estimates. In FY 2001, NASA's cost and schedule performance was 103 percent and 117 percent respectively. The life cycle cost and schedule are determined by the FY 2003 program budget request against the program original baseline budget.

Assessment

**Red**

**Annual Performance Goal 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.

Indicators

Each Field Center is reporting the operational downtime of the facilities indentified for inclusion in the measure.

Data Sources

Spacecraft data are taken from operational logs at the respective mission operations facilities. Other major facilities data are obtained from the NASA Facility Utilization on-line database https://nrpi.hq.nasa.gov/.

The four  NASA Enterprises responsible for spacecraft have established internal processes to record spacecraft unscheduled downtime data. The NASA Major Ground Facilities database collects the unscheduled downtime of ground facilities. Metrics were supplied by the NASA Centers, from which the subject spacecraft and ground facilities operation takes place.

Data Voids

None

Results

This metric reflects the effectiveness of NASA's engineering capability as demonstrated by facility availability. In FY 1999 and FY 2000, 6 percent and 3 percent of scheduled operating time were lost to unscheduled downtime, on average. In FY 2001, less than 1 percent of scheduled operating time was lost to unscheduled downtime, on average.

Assessment

**Blue**

**Annual Performance Goal 1P4**

Capture a set of best practices/lessons learned from each Program, to include at least one from each of the four Provide Aerospace Products and Capabilities subprocesses documented in NASA Procedures and Guidelines 7120.5, commensurate with current program status. Data will be implemented in PAPAC process improvement and in Program/Project Management training.

Indicators

The effectiveness of the PAPAC processes are to be evaluated via the formal collection and utilization of inputs from projects and program.

Data Sources

Lessons learned can be found on the NASA Lessons Learned Information System (LLIS) at http://llis.gsfc.nasa.gov. The NASA LLIS is an on-line, automated database system designed to collect and make available for use the NASA lessons learned from over the past 40 years.

Each of the five Enterprises ensures that at least one lesson learned or best practice per Program has been captured.

Data Voids

None

Results

Several programs and projects submitted "best practices/lessons learned" and all four of the PAPAC subprocesses were addressed, but many programs/projects did not provide input to the LLIS system.

Assessment

**Red**

**Annual Performance Goal 1P5**

Dedicate 10 to 20 percent of the Agency's Research & Development budget to commercial partnerships.

Indicators

Each of the Enterprises are reporting the value of their contribution to commercial partnerships.

Data Sources

The Office of Aerospace Technology's Commercial Technology Division administers this metric's collection and reporting by means of the NASA Commercialization Information System—NASA Technology Tracking System (TechTracS), the Agency-wide commercial technology management information system.

The Commercial Technology Division is supported by an Agency-wide team called the NASA Commercial Technology Management Team, which consists of the heads of each Center's Commercial Technology Office and a representative from each Enterprise. A NASA Commercialization Information System sub-team is led by the Langley Research Center. Each Commercial Technology Office ensures that appropriate and valid partnership data are entered into NASA TechTracS in a timely fashion.

Data Voids

None

Results

The percentage of NASA's Research and Development (R&D) budget dedicated to commercial partnerships affects integrated technology planning and development with NASA partners. In FY 1999 and FY 2000, the Agency contributed 13.9 and 19.1 percent of its R&D investment to commercial partnerships respectively. In FY 2001, NASA contributed 17.7 percent of its R&D investment to commercial partnerships.

The FY 2001 performance represents significantly high performance, which exceeds the goal. The National Performance Review goal for NASA is 10-20 percent of the R&D base.

Assessment

**Blue**

**Annual Performance Goal 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.

Indicators

Each of the Enterprises reports technology development activities leveraged through formal agreements.

Data Sources

Enterprise submissions to the NASA Technology Plan constitute the data sources for this goal.

The highest-ranking technology official in the Agency is the NASA Chief Technologist. Currently, the Chief Technologist is also the Associate Administrator for the Office of Aerospace Technology. The Chief Technologist also chairs the Technology Leadership Council, which includes the associate administrators for the Strategic Enterprise offices, 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. The Chief Technologist works with the Enterprises and the Field Centers to define the strategic technology areas that are critical to the Agency's long-term future and then tasks technology specialists at the Field Centers to develop plans in these areas. These plans become inputs to the technology managers at the Centers as they formulate the Enterprise Technology Plans and are subsequently reviewed by the Technology Leadership Council as part of the process for developing recommendations for technology priorities and a NASA budget for technology. The Chief Technologist is also responsible for the development of the NASA Technology Plan.

Data Voids

None

Results

Revision to the 1998 NASA Technology Plan was completed in FY 2001, and includes completed updates to both the Strategic Technology Areas, as well as the individual Enterprise sections. The Plan is accessible at http://technologyplan. nasa.gov/default.cfm?id=frontend.

Assessment

**Green**

**Annual Performance Goal 1P7**

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.

Indicators

- Develop and approve a Software Independent Verification and Validation Facility (IV&V) policy.
- Establish baseline for customer and stakeholder satisfaction.
- Establish baseline for the number of projects utilizing Software IV&V Facility.

Data Sources

Data were obtained from the Software IV&V Facility, and NASA Online Directives Information System (NODIS) available at http://nodis3.gsfc.nasa.gov/library/main_lib.html. The data were generated by the NASA Lead for the Software Engineering Initiative, in the Office of the Chief Engineer.

Data Voids

None

Results

This element builds significant consistency, discipline, and improvement of NASA's engineering capability.

NASA Policy Directive 8730.4, Software IV&V Policy was enacted on August 1, 2001, and placed in the NODIS Library. This policy is the foundation for the subsequently approved NASA IV&V Program Plan, August 9, 2001, and the draft NASA Procedures and Guidelines for Software IV&V Management, which is currently under review. The Facility drafted a customer satisfaction survey, which will be sent to participating projects and result in a baseline indicator by the end of FY 2002. A baseline of 16 NASA projects utilizing the NASA IV&V Facility was established and documented.

Assessment

**Green**

# Acronyms

# Acronyms

## A

| | |
|---|---|
| AACS | Attitude and Articulation Control Subsystem |
| ACE | Advanced Composition Explorer |
| ACS | Advanced Camera for Surveys |
| AGATE | Advanced General Aviation Transport Experiments |
| ALS | Advanced Life Support |
| AO | Announcements of Opportunity |
| AOC | Airline Operational Control |
| APG | Annual Performance Goal |
| APS | Advanced Pixel Sensor |
| ARC | Ames Research Center |
| ARC | Affiliated Research Center |
| ASM | All-Sky Monitor |
| ATC | Air Traffic Control |
| AVHRR | Advanced Very High Resolution Radiometer |
| AWS | Abrupt Wing Stall |

## B

| | |
|---|---|
| BAA | Broad Agency Announcement |
| BOREAS | Boreal Ecosystem-Atmosphere Study |
| BPR | Biological and Physical Research |
| BWB | Blended-wing-body |

## C

| | |
|---|---|
| CAN | Cooperative Agreement Notice |
| CAP | Collaborative Arrival Planner |
| CATSAT | Cooperative Astrophysics and Technology Satellite |
| CDR | Critical Design Review |
| CD-ROM | Compact Disc-Read Only Memory |
| CDS | Command & Data Subsystem |
| CERES | Clouds and Earth's Radiant Energy System |
| CFD | Computational Fluid Dynamics |
| CGBA | Commercial Generic Bioprocessing Apparatus |
| CISM | Center for Integrated Space Microsystems |
| CK | Communicate Knowledge |
| CLCS | Checkout and Launch Control System |
| CMOS | Complementary Metallic Oxide Semiconductor |
| CNN | Cable News Network |
| $CO_2$ | Carbon dioxide |
| CONDUIT | Control Designer's Unified Interfaces |
| CONTOUR | Comet Nucleus Tour |
| CPCG | Commercial Protein Crystal Growth |
| CRV | Crew Return Vehicle |
| CSC | Commercial Space Center |
| CTA | Cryogenic Telescope Assembly |
| CTAS | Center TRACON Automation System |
| CTV | Crew Transfer Vehicle |
| CXO | Chandra X-ray Observatory |

## D

| | |
|---|---|
| DA | Data Analysis |
| DAAC | Distributed Active Archive Center |
| dB | Decibel |
| DIF | Datalink Infrastructure Facility |
| DPT | Decadal Planning Team |

## E

| | |
|---|---|
| E/PO | Education and Public Outreach |
| ECS | EOSDIS Core System |
| EO-1 | Earth Observing 1 |
| EO-3 | Earth Observing 3 |
| EOCAP | Earth Observation Commercial Applications Program |
| EOS | Earth Observing System |
| EOS Terra | Earth Observing System Terra |
| EOSDIS | Earth Observing System Data and Information System |
| ERDAS | Earth Resources Data Analysis System |
| ERIM | Environmental Research Institute of Michigan |
| ESA | European Space Agency |
| ESE | Earth Science Enterprise |
| ESIP | Earth Science Information Partner |
| ESSP | Earth System Science Pathfinder |

| | |
|---|---|
| ESTOL | Extremely Short Takeoff and Landing |
| EUV | Extreme ultraviolet |
| EVA | Extravehicular Activity |

## F

| | |
|---|---|
| FACA | Federal Advisory Committee Act |
| FAME | Full-sky Astrometric Mapping Explorer |
| FAST | Fast Auroral Snapshot |
| FEM | Finite Element Models |
| FIRST | Far Infrared and Submillimeter Telescope |
| FUSE | Far Ultraviolet Spectroscopic Explorer |
| FY | Fiscal Year |

## G

| | |
|---|---|
| GALEX | Galaxy Evolution Explorer |
| GIS | Geography Information System |
| GLAST | Gamma Ray Large Space Telescope |
| GLOBE | Global Learning Observations for a Better Environment |
| GOES-M | Geostationary Operational Environmental Satellite-M |
| GP-B | Gravity Probe-B |
| GPMC | Goddard Program Management Council |
| GPS | Global Positioning System |
| GSFC | Goddard Space Flight Center |

## H

| | |
|---|---|
| HBCU | Historically Black Colleges and Universities |
| HEDS | Human Exploration and Development of Space |
| HEDS-UP | Human Exploration and Development of Space-University Partners |
| HERO | High-Energy Replicated Optics |
| HESSI | High Energy Solar Spectrographic Imager |
| HITS | Highways in the Sky |
| HPCC | High Performance Computing & Communications |
| HQ | Headquarters |
| HRF | Human Research Facility |
| HSI | Hispanic Serving Institutions |
| HST | Hubble Space Telescope |
| HTCI | HEDS Technology and Commercialization Initiative |
| HUMS | Health and Usage Monitoring Systems |

## I

| | |
|---|---|
| ICAO | International Civil Aviation Organization |
| ID | Identification |
| IFA | In-flight Anomaly |
| ILEC | Intelligent Life Extending Control |
| IMAGE | Imager for Magnetopause-to-Aurora Global Exploration |
| INTEGRAL | International Gamma-Ray Astrophysics Laboratory |
| IPG | Information Power Grid |
| ISDC | INTEGRAL Science Data Center |
| ISE | Intelligent Synthesis Environment |
| ISIS | Inflatable Shield in Space |
| ISS | International Space Station |
| ISTP | Integrated Space Transportation Plan |
| ISTP | International Solar-Terrestrial Physics |
| IV&V | Independent Verification & Validation |

## J

| | |
|---|---|
| JSC | Johnson Space Center |

## K

| | |
|---|---|
| keV | Kiloelectron volts |
| KSC | Kennedy Space Center |

## L

| | |
|---|---|
| LEO | Low-Earth Orbit |
| LOA | Letter of Agreement |

## M

| | |
|---|---|
| M2PT | MEIT 2 Processing Team |
| MAP | Microwave Anisotropy Probe |
| MARIE | Martian Radiation Environmental Experiment |
| MDI | Michelson Doppler Imager |
| MECA | Mars Environmental Compatibility Assessment |
| MEIT | Multiple-Element Integration Testing |
| MeV | Million electron volts |
| MFS | Multi-Functional Structures |
| MGS | Mars Global Surveyor |
| MIB | Mishap Investigation Board |
| MIDEX | Middle Explorer |
| MIP | MARS In-Situ Propellant Production Precursor |
| MISR | Multi-Angle Imaging Spectrometer |
| MIT | Massachusetts Institute of Technology |
| MOA | Memorandum of Agreement |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| MOPITT | Measurements of Pollution In The Troposphere |
| MOU | Memorandum of Understanding |
| MSG | Microgravity Science Glovebox |

## N

| | |
|---|---|
| NACA | National Advisory Committee for Aeronautics |
| NAI | NASA Astrobiology Institute |
| NAR | Non-Advocate Review |
| NAS | NASA Advanced Supercomputing |
| NASA | National Aeronautics and Space Administration |
| NCI | National Cancer Institute |
| NEAR | Near-Earth Asteroid Rendezvous |
| NEXT | NASA Exploration Team |
| NGST | Next Generation Space Telescope |
| NISN | NASA Integrated Services Network |
| NIX | NASA Image eXchange |
| NOAA | National Oceanic and Atmospheric Administration |
| NOx | Nitrogen oxide |
| NPG | NASA Procedures and Guidelines |
| NPR | National Performance Review |
| NRA | NASA Research Announcement |
| NRC | National Research Council |
| NREN | NASA Research and Education Network |
| NRL | Naval Research Laboratory |
| NSBRI | National Space Biomedical Research Institute |
| NSSDC | National Space Science Data Center |

## O

| | |
|---|---|
| OAT | Office of Aerospace Technology |
| OES | Office of Earth Sciences |
| OLMSA | Office of Life and Microgravity Science Applications |
| OSS | Office of Space Science |

## P

| | |
|---|---|
| PAPAC | Provide Aerospace Products and Capabilities |
| PCA | Propulsion Controlled Aircraft |
| PCS | Physics of Colloids in Space |
| PCU | Proportional Counter Unit |
| PDR | Preliminary Design Review |
| PI | Principal Investigator |
| ProSEDS | Propulsive Small Expendable Deployer System |

## Q

| | |
|---|---|
| QM | Qualification mirror |
| QoS | Quality of Service |
| QuickTOMS | Quick Total Ozone Mapping Spectrometer |

## R

| | |
|---|---|
| R&A | Research and Analysis |
| R&D | Research and Development |
| R&T | Research and Technology |
| REVCON | Revolutionary Concepts Program |
| RFP | Request for Proposals |

| | |
|---|---|
| RLV | Reusable Launch Vehicle |
| ROSS | Research Opportunities in Space Science |
| RVF | Rift Valley Fever |
| RXTE | Rossi X-Ray Timing Explorer |

## S

| | |
|---|---|
| SA3 | Solar Array 3 |
| SAGE | Stratospheric Aerosol and Gases Experiment |
| SAMPEX | Solar, Anomalous, and Magnetospheric Particle Explorer |
| SAPPHIRE | Satellite Data to Produce an Air Pollution Haze and Inherent Health Risk Atlas over Densely Populated Areas |
| SAR | Synthetic Aperture Radar |
| SATS | Small Aircraft Transportation System |
| SCIGN | Southern California Integrated GPS Network |
| SDO | Solar Dynamics Observatory |
| SeaWiFS | Sea-viewing Wide Field-of-view Sensor |
| SIM | Space Interferometry Mission |
| SIRTF | Space Infrared Telescope Facility |
| SLI | Space Launch Initiative |
| SMEX | Small Explorer Program |
| SOFIA | Stratospheric Observatory for Infrared Astronomy |
| SOHO | Solar Heliospheric Observatory |
| SOI | Silicon On Insulator |
| SRR | System Requirements Review |
| SScAC | Space Science Advisory Committee |
| SSMI | Special Sensor Microwave Imager |
| ST-3 | StarLight-3 |
| ST-5 | StarLight-5 |
| STAR | Subsonic Technology Assessment Research |
| STEREO | Solar Terrestrial Relations Observatory |
| STI | Scientific and Technical Information |
| STIS | Space Telescope Imaging Spectroscope |
| STOL | Short Takeoff and Landing |
| STS | Space Transportation System |
| SVS | Synthetic Vision System |
| SWAS | Submillimeter Wave Astronomy Satellite |

## T

| | |
|---|---|
| TCU | Tribal Colleges |
| TIMED | Thermosphere Ionosphere Mesosphere Energetics and Dynamics |
| TOMS | Total Ozone Mapping Spectrometer |
| TOMS-EP | Total Ozone Mapping Spectrometer Earth Probe |
| TOPEX | Topography Experiment |
| TPF | Terrestrial Planet Finder |
| TRACE | Transition Region and Coronal Explorer |
| TRACE-P | Transport and Chemical Evolution over the Pacific |
| TRACON | Terminal Radar Approach Control |
| TRL | Technology Readiness Level |
| TRMM | Tropical Rainfall Measuring Mission |
| TSC | Telescope Support Center |
| TWINS | Two Wide-angle Imaging Neutral-atom Spectrometer |

## U

| | |
|---|---|
| UCAV | Unmanned Combat Air Vehicle |
| UEET | Ultra-efficient engine technology |
| UF-1 | Utilization Flight-1 |
| UF-2 | Utilization Flight-2 |
| UHF | Ultra High Frequencies |
| UV | Ultraviolet |

## V

| | |
|---|---|
| VCL | Vegetation Canopy Lidar |
| VLBI | Very Long Baseline Interferometry |

## W

| | |
|---|---|
| WAN | Wide Area Network |
| WORF | Window Observational Research Facility |

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**NASA Headquarters**
Washington, DC 20546

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