Mission Directorate:	Science
Theme:	Astrophysics

Theme Overview

The science goals of NASA's Astrophysics Division are breathtaking: from investigating the very moment of creation of the universe, to learning the full history of the formation of stars and galaxies. NASA is discovering how planetary systems form, how environments hospitable for life develop, and is searching for signatures of life on other worlds may result in the discovery that we are not alone.

The Astrophysics Theme is comprised of the following major science-based programs:

- Physics of the Cosmos Program: Reveal laws and forces of the universe at the most fundamental level in ways that can only be done from space. Missions will probe back to the beginning of time by measuring the cosmic microwave background radiation in novel ways and using gravity waves as an entirely new window on the universe. The nature of dark matter that shepherds the growth of galaxies and large-scale structure will be determined, the mysterious dark energy pervading the universe will be uncovered and the limits of Einstein's theories will be tested.

- Cosmic Origins Program: Discover how the universe developed over cosmic time from the big bang to its modern configuration of galaxies, stars and planets. The focus is to explore how the expanding universe grew into a grand, cosmic web of galaxies; how within the galaxies stars and planets formed; and how stars create the heavy elements such as carbon, oxygen, and iron, that are essential for life.

- Exoplanet Exploration Program: Determine whether we are alone in the universe, by detecting and characterizing planets orbiting other stars in our galaxy. One of the most ambitious but captivating goals of NASA is to identify Earth-like worlds orbiting nearby stars and to search for the signatures of life.

The Astrophysics theme supports a robust research program, 10 operating missions, and 12 flight projects in various stages of planning and execution. As these missions explore the extremes of space, time, matter and energy, new scientific understanding is achieved and new technologies are developed and tested, resulting in great benefit to society and the economic and strategic health of our nation.

For more information, please see http://nasascience.nasa.gov/astrophysics

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**1,395.6**	**1,281.2**	**1,120.9**	**1,074.1**	**1,042.7**	**1,126.3**	**1,139.6**
Astrophysics Research	102.2	135.0	151.9	160.0	165.0	177.2	188.0
Cosmic Origins	870.1	819.2	667.2	598.9	550.3	523.8	452.3
Physics of the Cosmos	148.9	128.3	147.7	188.5	213.9	291.4	330.3
Exoplanet Exploration	156.7	68.1	46.2	57.3	86.9	123.5	167.3
Astrophysics Explorer	117.7	130.7	107.9	69.5	26.6	10.4	1.7
FY 2009 President's Budget Request	**1,337.5**	**1,162.5**	**1,122.4**	**1,057.1**	**1,067.7**	**1,116.0**	**--**
Astrophysics Research	102.2	152.3	170.4	181.0	203.0	198.9	--
Cosmic Origins	807.3	674.4	571.1	515.4	485.6	458.5	--
Physics of the Cosmos	159.0	157.0	219.8	249.0	271.1	326.0	--
Exoplanet Exploration	162.6	48.1	67.7	68.4	96.4	126.2	--
Astrophysics Explorer	106.4	130.6	93.3	43.3	11.7	6.4	--
Total Change from FY 2009 Request	**58.1**	**118.8**	**-1.5**	**17.1**	**-25.0**	**10.3**	**--**

Note: Starting in FY 10, the Astro-H project is in the Astrophysics theme.

Plans for FY 2010

Astrophysics Research

Senior Reviews for operating missions and archives were conducted in the spring of 2008; those results are reflected in the 2010 budget. A comparative evaluation of all Astrophysics operating missions is conducted every two years (next review scheduled for spring of 2010), and of the archives every four years. The science output is evaluated by an independent expert panel, and decisions are made as to which missions will receive funding for extended operation.

In R&A, peer-reviewed investigations are supported in the areas of past missions data analysis, and theoretical studies or modeling of the astrophysical phenomena targeted by past, current, and future missions. Laboratory studies of astrophysical phenomena, limited ground-based observing, and suborbital missions will also continue in FY 2010.

The Balloons Project will continue to work toward advancing the capability of the new super-pressure balloon, which will be used to carry large scientific experiments to the brink of space for 100 days or more.

Cosmic Origins

The James Webb Space Telescope was authorized to proceed into development in July, 2008, and the baseline cost and schedule have been established. The next major milestone is Critical Design Review, which is a review of the complete system design, and is scheduled to take place in March 2010.

Hubble Servicing Mission 4 and Servicing Mission Observatory Verification (SMOV) will be complete by the end of FY 2009 and peer-reviewed science will begin using the new instruments.

The Stratospheric Observatory For Infrared Astronomy (SOFIA) first science flights, which are the first competed science observations, will begin in FY 2010.

Physics of the Cosmos

Herschel and Planck in-orbit check-out will be complete and prime operations will begin. Fermi will remain in its prime operations phase and Chandra will continue on in extended operations.

Exoplanet Exploration

Kepler has launched successfully, in-orbit checkout is underway and science operations will begin in summer 2009.

Astrophysics Explorer

The High-Resolution Soft X-Ray Spectrometer (SXS) instrument was selected in 2008 as a Mission of Opportunity (MoO) and is scheduled to fly on the Japanese Astro-H mission in 2013. This instrument will be in the formulation phase in FY 2010.

The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will hold its confirmation review in preparation to enter development phase in FY 2010.

Relevance

Relevance to national priorities, relevant fields, and customer needs:

NASA enables research to understand the structure, content, and evolution of the universe. This research provides information about humankind's origins and fundamental physics that govern the behavior of matter, energy, space, and time. NASA leads the world in space-based research into the most compelling questions of modern physics, such as the nature of dark matter and dark energy, high-energy cosmic rays, tests of gravity and general relativity, and insight into cosmic inflation during the very early universe. NASA works proactively with the National Science Foundation and Department of Energy in exploring the interfaces between astronomy and physics, and in the search for life in the universe.

NASA-supported researchers look far into the universe, towards the beginning of time, to see the first stars and galaxies forming. They search for Earth-like planets around distant stars, determine if life could exist elsewhere in the galaxy, and investigate the processes that formed our solar system. These efforts are synergistic with Astrobiology, Solar System, Heliophysics and Earth science research supported elsewhere at NASA and in other federal agencies.

Astrophysics funds approximately 2000 research, data analysis and technology grants to research institutions and universities in most states. The proposed Astrophysics portfolio increases supporting research and technology funding in each of the strategic programs. These technology lines will focus on developing new capabilities from the prototype phase through the pre-flight phase, which will feed into flight programs. Astrophysics technology efforts have a long history of contributing to the defense sector (infrared detectors, interferometry, large optics), medical technology and life sciences (X-ray optics and detectors for cancer treatment, large format optical sensors, analysis software), homeland security (high energy detectors of fissile materials), and commercial applications (UV/X-ray photolithography advances in microelectronics, space-based telescopic platforms for Earth imaging).

Relevance to the NASA Mission and Strategic Goals:

Astrophysics supports NASA's achievement of Strategic Plan Sub-Goal 3D: Discover the origin, structure, evolution, and destiny of the universe, and search for Earth-like planets.

This effort is comprised of four focus areas, or Outcomes:
3D.1: Progress in understanding the origin and destiny of the universe, phenomena near black holes, and the nature of gravity.
3D.2: Progress in understanding how the first stars and galaxies formed, and how they changed over time into the objects recognized in the present universe.
3D.3: Progress in understanding how individual stars form and how those processes ultimately affect the formation of planetary systems.
3D.4: Progress in creating a census of extra-solar planets and measuring their properties.

Astrophysics seeks to answer these questions that humankind has been pondering for centuries: How did the universe begin? How will it end? What are the limits of matter and energy, of space and time? How did the universe come to be, and what are the laws of nature that have permitted life to arise in the universe? Throughout history, these questions have served as cornerstones of mythology and philosophy: thought-provoking, but unanswerable. Now, with the aid of cutting-edge science and technology, the answers are within reach.

See FY 2010 Performance Plan, under Management and Performance, for specific annual goals for this Theme.

Relevance to education and public benefits:

Stunning images produced from Astrophysics operating missions continue to inspire the public, revealing the beauty of our universe and the science behind those images. NASA provides the tools to translate the science for the classroom and other learning venues in ways that meet educator needs.

Hubble images are featured on the Space Telescope Science Institute's "Amazing Space" Web site which provides curriculum support tools to classrooms in every state in the union. Spitzer's "Cool Cosmos" Web site offers explorations into the world of the infrared, and Chandra delivers authentic data sets to educators to enhance lessons by allowing students to use the same data that professional researchers use.

A consortium of Astrophysics missions have been featured in a traveling museum exhibit, "Alien Earths", to inform and inspire the public on critical questions related to the search for life elsewhere in our universe. The Astrophysics Exoplanet Exploration Program, in conjunction with the Astronomical Society of the Pacific, has sponsored the creation of "Night Sky Network" amateur astronomy clubs around the nation. NASA also provides toolkits and professional development training to support these groups of space enthusiasts as they help strengthen the public understanding of astronomy and space science.

Mission Directorate:	Science
Theme:	Astrophysics

Performance Achievement Highlights:

For the first time, astronomers using the Chandra Space Telescope have clearly seen the effects of "dark energy" on the most massive collapsed objects in the universe. By tracking how dark energy has stifled the growth of galaxy clusters and combining this with previous studies, scientists have obtained the best clues yet about what dark energy is and what the destiny of the universe could be. These results have consequences for predicting the ultimate fate of the universe. If dark energy is explained by the cosmological constant, the expansion of the universe will continue to accelerate, and the Milky Way and its neighbor galaxy, Andromeda, may never merge with the Virgo cluster. For more information, please see: http://chandra.harvard.edu/index.html

Observations from the Hubble Space Telescope have provided new knowledge on the atmospheres of extrasolar planets. Hubble has made the first detection of an organic molecule in the atmosphere of a Jupiter-sized planet orbiting another star. This breakthrough is an important step in eventually identifying signs of life on a planet outside our solar system. The molecule found by HST is methane, which under the right circumstances can play a key role in prebiotic chemistry, the chemical reactions considered necessary to form life as we know it. This discovery proves that HST and upcoming space missions, such as NASA's James Webb Space Telescope (JWST), can detect organic molecules on planets around other stars by using spectroscopy, which splits light into its components to reveal the "fingerprints" of various chemicals. For more information on Hubble, please go to: http://hubble.nasa.gov/. And for JWST, please see: http://www.jwst.nasa.gov/

Hubble has also taken the first visible-light snapshot of a planet circling another star. Estimated to be no more than three times Jupiter's mass, the planet, called Fomalhaut b, orbits this bright southern star, located 25 light-years away in the constellation Piscis Australis, or the "Southern Fish."

On March 19, 2008, NASA's Swift satellite shattered the record for the most distant object (~7.5 billion light years away) that could be seen with the naked eye. The explosion was a gamma ray burst. Most gamma ray bursts occur when massive stars run out of nuclear fuel. Their cores collapse to form black holes or neutron stars, releasing an intense burst of high-energy gamma rays and ejecting particle jets that rip through space at nearly the speed of light like turbocharged cosmic blowtorches. When the jets plow into surrounding interstellar clouds, they heat the gas, often generating bright afterglows. Gamma ray bursts are the most luminous explosions in the universe since the big bang. For more information, please go to: http://swift.gsfc.nasa.gov/docs/swift/swiftsc.html

In June 2008, NASA launched the Fermi Gamma-Ray Space Telescope (formerly GLAST), which is now in its prime operations stage (http://fermi.gsfc.nasa.gov/). The JWST mission successfully entered the development phase and will launch in June 2014. The Kepler mission, designed to survey our region of the Milky Way Galaxy to detect and characterize hundreds of Earth-size and smaller planets in or nearby the habitable zone, completed all its environmental tests in 2008 and sucessfully launched March 6, 2009. For more information on Kepler, please go to: http://kepler.nasa.gov/

Mission Directorate:	Science
Theme:	Astrophysics

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	Senior Review Panel	04/2008	Comparative review of operating missions. Missions are ranked in terms of science return. In the most recent review, Swift and Chandra missions ranked highest, while RXTE and GP-B ranked lowest. Results and the report can be found at http://nasascience.nasa.gov/about-us/science-strategy/senior-reviews/AstroSR08_Report.pdf	04/2010
Relevance	National Research Council	05/2001	The Decadal Survey process began in 2008 and is underway. The last Decadal, which was published in 2001, prioritized science objectives in Astrophysics.	2010

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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**102.2**	**135.0**	**151.9**	**160.0**	**165.0**	**177.2**	**188.0**
Astrophysics Research and Analysis	**56.9**	**60.0**	**61.1**	**62.5**	**64.0**	**66.2**	**67.8**
Balloon Project	**24.0**	**24.6**	**26.7**	**28.8**	**32.4**	**33.2**	**35.8**
Other Missions and Data Analysis	**21.3**	**50.4**	**64.1**	**68.6**	**68.5**	**77.9**	**84.4**
FY 2009 President's Budget Request	**102.2**	**152.3**	**170.4**	**181.0**	**203.0**	**198.9**	**--**
Astrophysics Research and Analysis	**50.3**	**61.4**	**65.4**	**69.3**	**72.6**	**77.5**	**--**
Balloon Project	**22.8**	**24.6**	**26.7**	**28.8**	**32.4**	**33.2**	**--**
Other Missions and Data Analysis	**29.1**	**66.3**	**78.4**	**82.9**	**97.9**	**88.2**	**--**
Changes from FY 2009 Request	**0.0**	**-17.3**	**-18.5**	**-21.1**	**-38.0**	**-21.6**	**--**

Note: The Astrophysics R&A low-level technology development effort has moved into the program-specific Supporting Research & Technology lines with no impact to R&A.

Program Overview

The Astrophysics Research Program translates missions into science advances by: collecting, processing, and storing mission data; making mission data available to scientists; and funding grants for basic research, and data analysis from past and current missions. All data collected by missions are archived in data centers located at universities and NASA centers throughout the country and are readily available to all researchers and the general public.

Suborbital efforts (balloons and sounding rockets) are significant contributors to meeting the following goals: conducting cutting-edge basic research; developing tools of science; maintaining U.S. leadership in science, engineering, and technology; and training the next generation of scientists and engineers to better compete in the 21st century. For more information, please see: http://nasascience.nasa.gov/researchers/sara/highlights.

For more information on the Astrophysics Data Centers please see: http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers

Plans For FY 2010

The Astrophysics Research Program will continue to conduct and enable high-quality astrophysical research consistent with NASA's goals and science programs. Peer-reviewed investigations are supported in the areas of analysis of data obtained from past missions, theoretical studies or modeling of the astrophysical phenomena targeted by past, current, and future missions, laboratory studies of astrophysical phenomena, development of new detectors, limited ground-based observing, and suborbital missions.

Among the science areas pursued by the suborbital missions are rocket flights to study x-ray, ultraviolet, and infrared emission from both our galaxy and the early universe, and balloon flights to study cosmic rays from our galaxy, the polarization of the microwave background, and gamma rays from black holes in the nearby universe.

ADCAR covers the activities of the Astrophysics Data Centers and NASA's participation in the Virtual Astronomical Observatory (VAO). The VAO is a collaborative project between NASA and NSF.

The next Astrophysics Senior Review of operating missions is scheduled to be held in spring 2010, and the next archival Senior Review will be in 2012.

The Balloons project has approximately 18 flights planned for FY 2009, and a similar number is expected in FY 2010. Engineering data gathered will enable both the maturing of the science experiment technology for later flights and the development of next-generation super pressure balloons capable of supporting long duration science research (up to 100 days) at any Earth latitude.

In addition to ongoing awards, the Education and Public Outreach Project will competitively select approximately 40 new proposals for small awards averaging $15,000 a year and approximately 15 new proposals for mid-range awards averaging $130,000 a year. New Science Education and Public Outreach Forums will begin operation in FY 2010. In addition to community engagement and communication efforts, an analysis of the existing portfolio of NASA Earth and space science education products will be conducted.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

Project Descriptions and Explanation of Changes

Astrophysics Research & Analysis (R&A)

All Research and Analysis grants selected for funding by the Astrophysics Theme are broadly competed through NASA's Research Opportunities in Space and Earth Sciences (ROSES). Grant proposals must relate directly to both Agency and Theme goals and objectives, and all proposals are peer-reviewed by a mix of scientific disciplines and are selected based upon merit. Funded grants include theoretical investigations of phenomena related to missions, analysis of data from past missions, laboratory studies of astrophysical phenomena, development of new detectors and supporting technologies, some ground-based studies, and suborbital missions. The latter include both rocket flights to study x-ray, ultraviolet, and infrared emission from both our galaxy and the early universe, as well as balloon flights to study cosmic rays from our galaxy, the polarization of the microwave background, and gamma rays from black holes in the nearby universe

Balloons

Balloons have been used for decades to conduct scientific studies. While the basics of ballooning have not changed, balloon size and capabilities have increased, and their dependability has improved greatly. The Wallops Flight Facility manages the NASA Balloon Project. The project offers inexpensive, high-altitude flight opportunities for scientists to conduct research and test new technologies prior to spaceflight application. The science experiments being done by balloons cover a wide range of disciplines such as astrophysics, solar and heliospheric physics, as well as Earth upper-atmosphere chemistry.

Other Missions and Data Analysis

Included in this line item are the following projects:

-Astrophysics Data Curation and Archival Research (ADCAR): The Astrophysics Theme has established an archive structure beyond the scope of individual missions, to receive data and make it accessible by creating an ensemble of primarily wavelength-specific astrophysics archives. After the completion of a mission, all archive activities are taken over by the relevant active multi-mission archive. ADCAR covers the activities of the Astrophysics Data Centers and NASA's participation in the Virtual Astronomical Observatory (VAO). ADS maintains bibliographic databases and is one of the data centers supported in the ADCAR activity. For more information see: http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers

-The Astrophysics Senior Review is conducted every two years and is a comparative evaluation of all operating missions in their extended phase. Science output for these missions is evaluated, and a ranking process determines which missions will continue to receive funding for extended operations.

-Keck Single Aperture is a data archive for the High Resolution Echelle Spectrometer (HIRES) instrument. This instrument provides the radial velocity data used to find exoplanets.

-Directorate Support - Space Science: This project funds Agency-wide Fee for Services for the Science Mission Directorate. These fees for services include Defense Contract Audit Service (DCAS) contract administration, Defense Contract Audit Agency (DCAA) audit services and NASA Contract Assurance Services (NCAS) for all of SMD's projects.

-Education and Public Outreach: Education and Public Outreach: This project is a major contributor to the overall NASA education and outreach effort through development and dissemination of new educational and outreach products that utilize SMD science discoveries and by providing opportunities for students and educators, citizen scientists, and the public to engage in authentic experiences working with our data and our research communities. Efforts are carried out through competitively selected awards. There are small awards averaging $15,000 a year and larger award averaging $130,000 per year. The project also supports four Science Education and Public Outreach Forums to foster ongoing engagement of the target audiences through community communication and feedback.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Annual peer-reviewed solicitation for research grant opportunities	Research Program	No change

Program Management

The Science Mission Directorate provides program management, with individual projects managed at Goddard Space Flight Center and the Jet Propulsion Laboratory.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Research

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Archival Senior Review Panel	05/2008	Comparative review of archives efficiency and cost effectiveness. The normal review cycle for activities at archive centers is 4 years, for more information on the 2008 Senior Archival review see: http://nasascience.nasa.gov/astrophysics/astrophysics-data-centers/ApArchSR-2008_final.pdf	05/2012
Quality	Balloon working group	06/2008	Review the operations from a scientific standpoint. The outcome of 2008 BWG meeting was that much had been accomplished to increase the reliability of flight and termination systems, Solution to chute shock problem, Rip stitch decelerator, and dragging payloads. The development of the mini-SIP will enable many new small science investigations. There has been a major step forward in solving the deployment problem for the lobed design (super pressure balloon).	06/2009

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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**870.1**	**819.2**	**667.2**	**598.9**	**550.3**	**523.8**	**452.3**
Hubble Space Telescope (HST)	**244.9**	**207.7**	**112.6**	**101.6**	**94.6**	**91.1**	**93.2**
James Webb Space Telescope (JWST)	**510.3**	**446.9**	**441.4**	**385.1**	**354.6**	**335.6**	**259.8**
Stratospheric Observatory for Infrared Astronomy (SOFIA)	**63.8**	**72.8**	**72.8**	**74.0**	**75.8**	**77.6**	**79.1**
Other Missions And Data Analysis	**51.2**	**91.7**	**40.4**	**38.3**	**25.3**	**19.4**	**20.2**
FY 2009 President's Budget Request	**807.3**	**674.4**	**571.1**	**515.4**	**485.6**	**458.5**	**--**
Hubble Space Telescope (HST)	**228.5**	**154.9**	**125.6**	**114.7**	**94.8**	**93.9**	**--**
James Webb Space Telescope (JWST)	**448.3**	**371.9**	**311.1**	**265.1**	**236.1**	**194.9**	**--**
Stratospheric Observatory for Infrared Astronomy (SOFIA)	**62.1**	**72.8**	**72.8**	**57.0**	**58.8**	**60.6**	**--**
Other Missions and Data Analysis	**68.4**	**74.7**	**61.6**	**78.6**	**95.9**	**109.1**	**--**
Changes from FY 2009 Request	**62.8**	**144.8**	**96.1**	**83.5**	**64.7**	**65.2**	**--**

Note: Includes $75M of Recovery Act funding in FY09. Hubble Fellowship funding, as well as project management funds, have been moved into program-level activities; there is no budgetary impact to Hubble operations.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Program Overview

The science goal of Cosmic Origins is to understand the entire sweep of evolution of the universe, from the cosmic big bang to the present. How did the rich structure we observe in the universe today, its planets, stars and galaxies, originate from the tiny fluctuations in the density of matter and energy imprinted by the big bang? What was the nature of the first stars and galaxies, which are so faint and distant that they have never been observed? How did galaxies and the enormous black holes within them form and evolve? How do stars and planets form? What are the conditions needed for life to originate? Are we alone? To address these fundamental questions NASA has developed the world's most sophisticated space observatories and is now building even more advanced facilities.

Cosmic Origins missions explore how the expanding universe grew into a grand, cosmic web of galaxies; how stars and planets formed within the galaxies; how stars create the heavy elements, such as carbon, that are essential for life. Major breakthroughs in our knowledge of the cosmos have already been made with the current suite of missions. But Cosmic Origins science questions will remain vital, even post-JWST. The submillimeter and far-infrared parts of the spectrum are just now being examined by missions like Herschel and SOFIA. In the future, larger telescopes (with mirror diameters of 10 meters or longer) will be required to resolve galaxies and stellar nurseries at these wavelengths and in the ultraviolet. Future collaboration will also be critical for continued progress answering the questions that form the intellectual impetus behind Cosmic Origins.

For more information, please see: http://nasascience.nasa.gov/about-us/smd-programs/cosmic-origins

Plans For FY 2010

Hubble Space Telescope Servicing Mission 4 and the in-orbit checkout of instruments will be complete, and peer-reviewed proposals will begin with the new instruments.

JWST was authorized to proceed into development in July, 2008 and the baseline cost and schedule have been established. The next major milestone, Critical Design Review is scheduled to take place in March 2010, which will result in a review of the complete system design.

SOFIA basic science flights will be the first openly competed science to the general astronomical community; the science will be conducted on two instruments aboard SOFIA: FORCAST (U.S. instrument) and GREAT (German instrument). First science is now scheduled to begin in FY 2010 while the project continues progress toward Limited Operations Capability in 2011.

Spitzer cryogen will run out in spring 2009; the spacecraft will be in its warm operations phase, using remaining imaging capabilities that still exceed what is available from the ground, and will be unmatched until the launch of JWST. Warm Spitzer will be a powerful and unique facility for projects that require precise photometry, and for deep large-scale surveys at near/mid-infrared wavelengths. The spacecraft is funded for two years of warm operations, per results of the 2008 operating missions Senior Review. Spitzer will be reviewed again in the 2010 Senior Review to determine whether to extend warm operations.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Project Descriptions and Explanation of Changes

Hubble Space Telescope (HST)

Hubble Space Telescope launched in 1990 and is currently in an extended operations phase. Servicing Mission 4 (SM4), scheduled for May, 2009, will add new batteries, gyros and instruments to extend its life even further into the future. One of NASA's most successful and long-lasting science missions, HST has beamed hundreds of thousands of images back to Earth, shedding light on many of the great mysteries of astronomy. Its gaze has helped determine the age of the universe, the identity of quasars, and the existence of dark energy.

James Webb Space Telescope

JWST is in development phase. The spacecraft will have a large mirror, 21.3 feet in diameter, and a sunshield the size of a tennis court. Neither the mirror nor the sunshield fit into the rocket fully open, so both will fold up and open only after JWST is in space. JWST will reside at the Sun-Earth L2 point, which is about one million miles from the Earth. The telescope and instruments will operate at cryogenic temperature in order to achieve infrared performance. JWST is currently in development phase and launch is scheduled for 2014 on a European Space Agency-supplied Ariane-5 rocket for a five-year science mission (10-year goal) to study the origin and evolution of galaxies, stars, and planetary systems.

Stratospheric Observatory for Infrared Astronomy (SOFIA)

SOFIA is in development phase. Astronomical objects emit many forms of energy, which neither the human eye nor ordinary telescopes can detect. Infrared is one form of this invisible energy. SOFIA is a Boeing 747SP airborne observatory with a 2.5 meter reflecting telescope that will study the universe in the infrared spectrum. Besides this contribution to science progress, SOFIA will be a major factor in the development of new observational techniques, of new instrumentation and in the education of young scientists and teachers in the discipline of infrared astronomy. The project will be at Full Operational Capability (FOC) in 2014.

Other Missions and Data Analysis

Included in this line item are:

-The Spitzer Space Telescope, in extended operations, is an infrared cryogenic telescope equipped with three instruments to study the characteristics of star-forming regions, centers of galaxies, and newly forming planetary systems. Spitzer will complete its cryogenic mission by mid-2009, but funding to operate a warm mission phase was approved as a result of the latest Astrophysics Division operating missions Senior Review. Continued warm operations will be reviewed in the 2010 Senior Review.

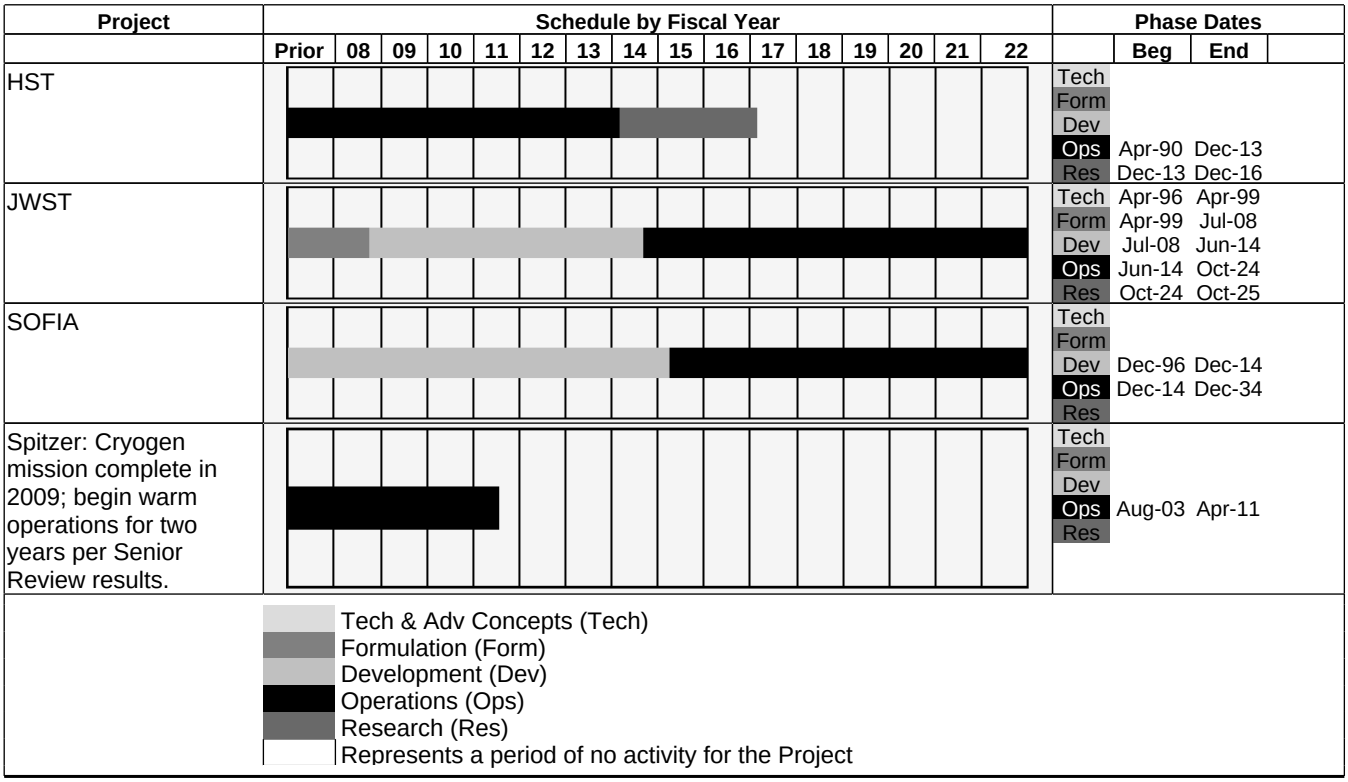
-Cosmic Origins Supporting Research & Technology, which supports Hubble fellowships and program-specific research and early technology development efforts.

-Cosmic Origins Future Missions which supports future mission studies based on the recommendations of the upcoming Astrophysics decadal review.

-Cosmic Origins Program Management which provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Implementation Schedule



Program Management

Cosmic Origins project management responsibility is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
HST	GSFC	GSFC	None
JWST	GSFC	None	European Space Agency (ESA) and Canadian Space Agency (CSA)
SOFIA	DFRC	DFRC & ARC	German Space Agency (DLR)
Spitzer	JPL	JPL	None

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins

Acquisition Strategy

HST: All major acquisitions are in place for operations and servicing. Space Telescope Science Institute, Baltimore, MD and Ball Aerospace and Technologies Corp., Boulder, CO are providing support for SM4. For HST Operations, the Space Telescope Science Institute coordinates with the Hubble European Space Agency Information Center.

JWST: JWST is being built by Northrop Grumman Aerospace Systems (Redondo Beach, CA), teamed with Ball (Boulder, CO), ITT (Rochester, NY) and Alliant Techsystems (Edina, MN). Selections were made via a competitive NASA Request For Proposal.

SOFIA: L3 Communications (Waco,Texas), and MPC Products Corporation (Skokie,IL) are supporting the completion of the development, integration and test of the airborne platform system. L3 modified the SOFIA 747SP aircraft to install the telescope provided by Germany (DLR/DSI). MPC is developing the telescope cavity door drive system. CSC DynCorp (El Segundo, CA) is providing aircraft maintainence support. University Space Research Association (Columbia, MD) will manage the science planning, ground science facilities, science instrument and technology development, and education and public outreach for SOFIA.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**1,575.0**	**510.3**	**446.9**	**441.4**	**385.1**	**354.6**	**335.6**	**259.8**	**634.9**	**4,943.6**
Formulation	1,575.0	225.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,800.1
Development / Implementation	0.0	285.2	446.9	441.4	385.1	354.6	335.6	259.8	52.5	2,561.1
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	582.4	582.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**1,575.0**	**448.3**	**371.9**	**311.1**	**265.1**	**236.1**	**194.9**	**--**	**0.0**	**3,402.5**
Formulation	1,575.0	225.1	0.0	0.0	0.0	0.0	0.0	--	0.0	1,800.1
Development / Implementation	0.0	223.2	371.9	311.1	265.1	236.1	194.9	--	0.0	1,602.3
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.1
Changes from FY 2009 Request	**0.0**	**61.9**	**75.0**	**130.3**	**120.0**	**118.5**	**140.7**	**--**	**634.9**	**1,541.1**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	62.0	75.0	130.3	120.0	118.5	140.7	--	52.5	958.8
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	582.4	582.4
Other	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1

Note: The FY 2010 LCC number in the table above is understated by $20M due to the difference in the FY 2009 enacted bill and the April 2009 initial operating plan. The FY 2010 JWST baseline LCC is $4,964M, and the Development estimate is $2,581.1M. The FY 2009 Budget Request Prior and BTC figures did not reflect an approved baseline.

Explanation of Project Changes

JWST entered development in late 2008 and the budget and schedule are at a 70% confidence level as a result of the confirmation review process. The newly baselined life-cycle cost is based on a June, 2014 launch readiness date, including costs from formulation through the end of operations. The life-cycle cost incorporates actual costs to date, including long lead items that have already been produced or are currently being manufactured, as well as cost estimates for the remaining work. The cost includes five years of operations (with consumables sufficient for 10 years of operations), data analysis, archiving, and project close-out.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Purpose

The James Webb Space Telescope (JWST) was identified by the National Research Council as a top priority new initiative for astronomy and physics for the decade. JWST is a large, deployable, space-based infrared astronomical observatory, scheduled for launch in 2014. The mission is a logical successor to the Hubble Space Telescope (HST), extending beyond Hubble's discoveries by looking into the infrared spectrum, where the highly red-shifted early universe must be observed, where cool objects like protostars and protoplanetary disks emit strongly, and where dust obscures shorter wavelengths.

Hubble has told us much about distant objects, but its infrared coverage is limited. Light from distant galaxies is redshifted, by the expansion of the universe, into the infrared part of the spectrum (from the visible). By examining light redshifted beyond Hubble's sight, JWST will be able to observe things farther away, as their light has taken longer to reach us. Hence it will be looking back further in time.

JWST will explore the mysterious epoch when the first luminous objects in the universe came into being after the big bang. The focus of scientific study will include first light of the universe, assembly of galaxies, origins of stars and planetary systems, and origins of the elements necessary for life.

The telescope is scheduled to launch in 2014 from Kourou, French Guiana, on an ESA-supplied Ariane 5 rocket. Its operational location is the L2 Lagrange point, which is about one million miles from the Earth.

For more information, please see: http://www.jwst.nasa.gov/

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Parameters

JWST will be optimized for infrared astronomy, with some capability in the visible range. JWST's instruments are: Near Infrared Camera (NIRCam); Mid Infrared Instrument (MIRI); Near Infrared Spectrograph (NIRSpec); and the Fine Guidance Sensor (FGS).

NIRCam is an imager with a large field of view and high angular resolution. It covers a wavelength range of 0.6 - 5 micrometers and has 10 mercury-cadmium-telluride (HgCdTe) detector arrays. These are analogous to CCDs found in ordinary digital cameras. NIRCam is a science instrument but also a wavefront sensor, which is used to align and focus the optical telescope.

NIRSpec enables scientists to obtain simultaneous spectra of more than 100 objects in a 9-square-arcminute field of view. It provides medium-resolution spectroscopy over a wavelength range from 0.6 - 5 micrometers. NIRSpec employs a micro-electromechanical system "microshutter array" for aperture control, and it has two HgCdTe detector arrays.

MIRI is an imager/spectrograph that covers the wavelength range of 5 - 28 micrometers and it has three Arsenic-doped Silicon detector arrays. The camera module provides wide-field broadband imagery, and the spectrograph module provides medium-resolution spectroscopy over a smaller field of view compared to the imager. The nominal operating temperature for the MIRI is 7 degrees above absolute zero, which is possible through an on-board cooling system.

The FGS is a guider camera that is incorporated into the instrument payload in order to meet the image motion requirements of JWST. This sensor is used for both "guide star" acquisition and fine pointing. The sensor operates over a wavelength range of 1 - 5 micrometers and has two HgCdTe detector arrays. Its field of view provides a 95% probability of acquiring a guide star for any valid pointing direction.

The FGS Tunable Filter Camera is a wide-field, narrow-band camera that provides imagery over a wavelength range of 1.6 - 4.9 micrometers, via tunable Fabry-Perot etalons that are configured to illuminate the detector array with a single order of interference at a user-selected wavelength. The camera has a single HgCdTe detector array.

JWST will continue modifications to the thermal vacuum Chamber A at the Johnson Space Center to achieve the required temperature and contamination control test conditions for hardware prior to flight. The first phase of this project is underway and is funded with a total of $20.4M of FY 2008 and FY 2009 funds. The total cost of the modification remains at $60.6M, $28.0M of which is FY 2010 funding.

The JWST Ground Operations, Science Support Center and archives will be at the Space Telescope Science Institute in Baltimore, MD.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Commitments

JWST is scheduled to launch in 2014 and, after six months of on-orbit checkout and commissioning, complete five years of mission operations (with a goal of 10 years of operations.)

The four main science goals are:
- Search for the first galaxies or luminous objects formed after the big bang.
- Determine how galaxies evolved from their formation until now.
- Observe the formation of stars from the first stages to the formation of planetary systems.
- Measure the physical and chemical properties of planetary systems and investigate the potential for life in those systems.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Observatory	Northrop Grumman Aerospace Systems, Redondo Beach, California	Includes Optical Telescope Element (OTE), Spacecraft, Sunshield, Observatory AI&T and commissioning. The Observatory shall be designed for at least a 5-year lifetime.	N/A	Same
Integrated Science Instrument Module (ISIM)	NASA Goddard Space Flight Center	Contains the Science Instruments (SIs) and Fine Guidance Sensor (FGS). Provides structural, thermal, power, command and data handling resources to the SIs and FGS.	N/A	Same
Near-Infrared Camera (NIRCam) instrument	University of Arizona; Lockheed Martin	Optimized for finding first light sources, and operating over the wavelength range 0.6-5 microns.	N/A	Same
Near-Infrared Spectrometer (NIRSpec)	European Space Agency (ESA)	Operating over the wavelength range 0.6-5 microns with three observing modes.	N/A	Same
Mid-Infrared Instrument (MIRI)	ESA; University of Arizona; Jet Propulsion Laboratory	Operating over the wavelength range 5-27 microns, providing imaging, coronagraphy, and spectroscopy.	N/A	Same
Fine Guidance Sensor	Canadian Space Agency (CSA)	Provides scientific target pointing information to the observatory's attitude control sub-system.	N/A	Same
Launch Vehicle	European Space Agency (ESA)	Ariane V ECA	N/A	Same
Science Operations Center and Mission Operations	Space Telescope Science Institute (STScI)	Mission Operations and Science Operations Center	N/A	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Schedule Commitments

JWST was approved to enter implementation in July, 2008.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
Non-Advocate Review/Preliminary Design Review	March, 2008	N/A	Same
Start phase C/Implementation	July, 2008	N/A	Same
Critical Design Review	March, 2010	N/A	Same
Systems Integration Review (SIR)	May, 2012	N/A	Same
Launch Readiness Date	June, 2014	N/A	Same
Start Phase E	December, 2014	N/A	Same

Development Cost and Schedule Summary

JWST

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
James Webb Space Telescope	2009	2,581.1	2009	2,581.1	0	Launch	6/15/2014	6/15/2014	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**2,581.1**	**2,581.1**	**0.0**
Payload	178.4	178.4	0.0
Spacecraft	875.4	875.4	0.0
Systems I&T	67.3	67.3	0.0
Ground Systems	206.8	206.8	0.0
Science/technology	10.5	10.5	0.0
Other (launch services, project management, etc.)	1,242.7	1,242.7	0.0

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Project Management

Goddard Space Flight Center is responsible for James Webb Space Telescope project management.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Observatory	GSFC	GSFC	None
Mission management and System Engineering	GSFC	GSFC	None
Integrated Science Instrument Module (ISIM)	GSFC	GSFC	None
NIRCam	GSFC	GSFC	None
NIRSpec	ESA	None	ESA
MIRI	GSFC	JPL, ARC	ESA
Fine Guidance Sensor - Tunable Filter (FGS-TF)	CSA	None	CSA
Ariane 5 ESA launch vehicle and launch operations	ESA	None	ESA
Ground control systems and science operations and control center	GSFC	None	None

Acquisition Strategy

JWST is being built by Northrop Grumman Aerospace Systems (Redondo Beach, CA), teamed with Ball (Boulder, CO), ITT (Rochester, NY) and Alliant Techsystems (Edina, MN). Selections were made via NASA Request For Proposal.

The Space Telescope Science Institute (STScI), in Baltimore, MD, is developing the Science and Operations Center and associated services.

The Integrated Science Instrument Module (ISIM) is being provided by GSFC.

The University of Arizona, Tucson, is providing the near-infrared science camera (NIRCam), along with Lockheed Martin's Advanced Technology Center in Palo Alto, California. The selection was made via a NASA Announcement of Opportunity.

The European Space Agency is providing the Mid-Infrared Instrument, (MIRI) with management and technical participation by ARC and JPL, which was selected for this role after an internal NASA competition. The Europeans are also providing the Near-Infrared Spectrometer (NIRSpec) and an Ariane 5 launch vehicle.

The Canadian Space Agency is providing the Fine Guidance Sensor.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	James Webb Space Telescope

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	Critical Design Review	03/2010
Performance	SRB	N/A	Systems Integration Review/Authority to Proceed into Assembly Integration and Testing	05/2012
Performance	SRB	N/A	Test Readiness Review/Authority to Proceed with Environmental Testing	03/2013
Performance	SRB	N/A	Pre-ship Review/Authority to Ship to Launch Site	10/2013
Performance	SRB	N/A	Flight Readiness Review/Authority to Launch	06/2014

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
JWST Manufacturing, I&T	JWST has a long, complicated cryogenic integration and test which has never been performed at this scale.	JWST Standing Review Board regularly reviews the optical telescope element (OTE) testing and observatory-level integration and test planning.
JWST Advanced Technology Development Risk	JWST requires advances in several technologies, which could present cost and schedule problems.	Successful Technology Non-Advocate Review (T-NAR) held in January 2007; risk retired.
JWST Partnership Risk	Because JWST is an international collaboration, NASA may incur schedule and cost impacts caused by challenges in Europe and Canada that are outside of NASA's control. Experience with similar collaborations indicates that this is likely to occur.	NASA has written clearly-defined interfaces and is actively managing and complying with export controls (ITAR).

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**596.2**	**63.8**	**72.8**	**72.8**	**74.0**	**75.8**	**77.6**	**79.1**	**1,843.4**	**2,955.5**
Formulation	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0
Development / Implementation	561.2	63.8	72.8	72.8	74.0	75.8	77.6	79.1	0.0	1,077.1
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,843.4	1,843.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**595.6**	**62.1**	**72.8**	**72.8**	**57.0**	**58.8**	**60.6**	**--**	**1,599.4**	**2,579.0**
Formulation	35.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	35.0
Development / Implementation	560.6	62.1	72.8	72.8	57.0	58.8	60.6	--	0.0	944.7
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	1,599.4	1,599.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1
Changes from FY 2009 Request	**0.6**	**1.8**	**0.0**	**0.0**	**17.0**	**17.0**	**17.0**	**--**	**244.1**	**376.5**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.6	1.7	0.0	0.0	17.0	17.0	17.0	--	0.0	132.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	244.0	244.0
Other	0.0	0.1	0.0	0.0	0.0	0.0	0.0	--	0.1	0.1

Explanation of Project Changes

The FY09 Budget runout for FY 2011 and beyond assumed that an international partner would be identified to pay some of SOFIA's operational costs. NASA is no longer expecting to rely on an additional partner and has restored funds to SOFIA's operations budget. Also, because attainment of Full Operational Capability is scheduled for December 2014, the Development budget is projected to continue through FY 2014, with Operations starting in FY 2015.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Purpose

Mission objectives for SOFIA include studying many different kinds of astronomical objects and phenomena, but some of the most significant are: star birth and death; formation of new solar systems; identification of complex molecules in space; planets, comets and asteroids in our solar system; nebulae and dust in galaxies (ecosystems of galaxies); and black holes at the center of galaxies. SOFIA's breadth of coverage serves many scientific quests. It will be NASA's only far-infrared mission when Spitzer runs out of helium, and it is the only mid-infrared mission until JWST. SOFIA's reconfigurability and flexibility ensures cutting edge technology as well as the ability to address new scientific questions. At full operational capability, SOFIA will have eight instruments (6 U.S. instruments; 2 German instruments). The U.S. instruments include: High-speed Imaging Photometer for Occultation (HIPO), First Light Infrared Test Experiment CAMera (FLITECAM), Faint Object InfrRed CAmera for the SOFIA Telescope (FORCAST), CAltech Submillimeter Interstellar Medium Investigations Receiver (CASIMIR), Echelon-Cross -Echelle Spectrograph (EXES), and High-resolution Airborne Wideband Camera (HAWC). The two German instruments are German Receiver for Astronomy at Terahetz Frequencies (GREAT), and Field Imaging Far-Infrared Line Spectrometer (FIFI LS).

For more information, please see: http://www.nasa.gov/mission_pages/SOFIA/index.html

Project Parameters

The Stratospheric Observatory for Infrared Astronomy (SOFIA) was designed as a highly-modified 747SP aircraft with a large open-port cavity aft of the wings, housing a 2.5 meter telescope optimized for infrared/sub-millimeter wavelength astronomy. SOFIA will operate in flight at 41,000 feet using six U.S. instruments and two German instruments. SOFIA will ramp up to 960 science hours per year. Early science instruments will include: High-speed Imaging Photometer for Occultations (HIPO); First Light Infrared Test Experiment Camera (FLITECAM); and German Receiver for Astronomy at Terahertz frequencies (GREAT). These will be followed by six other instruments in the later phases: flights will last six to eight hours on average.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Commitments

SOFIA will initiate science observations in 2010, and will begin 20 years at full operational capability as an airborne observatory in 2014.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Platform	DFRC/L3/MPC/DLR	747SP modified to carry an 18 ton, 2.5 meter telescope	Same	Same
Science Center	ARC/USRA	Science Center will schedule observations, and manage data acquisition and processing	Same	Same
Science Instruments	USRA/Universities	6 U.S. instruments ranging from Infrared to submillimeter	Same	Same
Flight Operations	DFRC/CSC DyneCorp	Flight crew, maintenance, and fuel	Same	Same
High-speed Photometer for Occultations	Lowell Observatory	Simultaneous high-speed time-resolved imaging photometry at two optical wavelengths	Same	Same
First Light Infrared Test Experiment Camera	UCLA	Large field-of-view, narrow- and broad-band photometric imaging and low-resolution spectroscopy from 1 to 5.5 µm	Same	Same
A Wide-field Infrared Camera for SOFIA	Cornell University	Large field-of-view, narrow- and broad-band photometric imaging and moderate-resolution spectroscopy from 4 to 42 µm	Same	Same
Caltech Submillimeter Interstellar Medium Investigations Receiver	Caltech	Modular, dual-channel heterodyne instrument for high-resolution spectroscopy between 150 and 600 µm	Same	Same
High-resolution Airborne Wide-band Camera	University of Chicago Yerkes Observatory	Broad-band, far-infrared camera with four bands between	Same	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Schedule Commitments

The development and test plan has been modified to enable earlier science observations by the science community to be concurrent with the late phases of aircraft flight testing. The current plan provides for initial science observations with a subset of science instruments in 2010, followed by completion of the remaining science instruments and refinement of telescope performance, at which point Full Operational Capability (in December 2014) is reached.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
First Flight	2000	2007	2007
First Science (Early Science)	N/A	2009	2010
Full Operational Capability (FOC)	N/A	2014	2014

Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Stratospheric Observatory for Infrared Astronomy (SOFIA)	2007	919.5	2009	1,077.1	17	FOC	12/30/2013	12/30/2014	12

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**919.5**	**1,077.1**	**157.6**
Aircraft/Spacecraft	657.7	710.2	52.5
Other Costs	62.2	151.5	89.3
Science/Technology	199.6	215.4	15.8

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Cosmic Origins
Project In Development:	Stratospheric Observatory for Infrared Astronomy (SOFIA)

Project Management

The overall Stratospheric Observatory for Infrared Astronomy (SOFIA) project, and the SOFIA airborne system is managed by Dryden Flight Research Center. The SOFIA science is managed by Ames Research Center.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Platform	DFRC	DFRC	Germany - DLR/DSI
Science	ARC	None	Germany - DLR/DSI
Mission Operations and Data Analysis	ARC	None	Germany - DLR/DSI
Instruments (9)	ARC	None	Germany - DLR/DSI

Acquisition Strategy

Dryden Flight Research Center (DFRC) handles the platform project (airframe and telescope). DFRC is working with L-3 Communications (Waco,Texas), and MPC Products Corporation (Skokie,IL) to support the completion of the development, integration and test of the airborne platform system. L-3 modified the SOFIA 747SP aircraft to install the telescope provided by Germany (DLR/DSI). MPC is developing the telescope cavity door drive system. DFRC is also working with CSC DynCorp (El Segundo, CA) which is providing aircraft maintainence support.

Ames Research Center (ARC) handles the science management. ARC is working with University Space Research Association (Columbia, MD) to manage the science planning, ground science facilities, science instrument and technology development, and education and public outreach for SOFIA.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SMOR - Independent Team	7/2008	Assess the science operations. Main finding was to make SOFIA science data available to general community	N/A
Performance	Standing Review Board	N/A	Early science project review	12/2009

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Late delivery of Cavity Door Drive System	Late delivery of software that operates the telescope observation doors on the aircraft will impact the schedule to initiate open door flight testing and science observations.	NASA has stationed a NASA representative at the vendor's facility to support and oversee the vendor until delivery of the software. NASA has reviewed and revised the schedule for testing of the software for schedule efficiency.

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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**148.9**	**128.3**	**147.7**	**188.5**	**213.9**	**291.4**	**330.3**
Other Missions and Data Analysis	**148.9**	**128.3**	**147.7**	**188.5**	**213.9**	**291.4**	**330.3**
FY 2009 President's Budget Request	**159.0**	**157.0**	**219.8**	**249.0**	**271.1**	**326.0**	**--**
Other Missions and Data Analysis	**159.0**	**157.0**	**219.8**	**249.0**	**271.1**	**326.0**	**--**
Changes from FY 2009 Request	**-10.1**	**-28.8**	**-72.1**	**-60.5**	**-57.1**	**-34.6**	**--**

Program Overview

The Physics of the Cosmos (PCOS) Program focuses on some of the most profound questions in contemporary science: How did the universe begin? What is the universe composed of, and what is its ultimate fate? What are the fundamental laws that govern the workings of space, time, matter and energy?

These fundamental questions can be approached by asking more specific questions: What happens to matter, energy, and time at the edge of a black hole, where Einstein's theory of gravity is put to its harshest test? What is the nature of dark matter and dark energy which pervade the universe?

It is possible that the answers to these questions will usher in a revolutionary new paradigm of physics. It is the goal of the PCOS Program to observe and study those phenomena in the cosmos, from observing the most energetic regions in the universe, those near the surfaces of super massive black holes, to peering back to the very beginning of time using the completely unexplored spectrum of gravitational radiation. The Fermi mission, for example, will search for signs of new laws of physics and what composes the mysterious dark matter. It will attempt to explain how black holes accelerate immense jets of material to nearly light speed. The XMM-Newton mission has helped scientists solve a number of cosmic mysteries, ranging from enigmatic black holes to the origins of the universe itself. Chandra will reveal new details about phenomena in our universe as scientists can now see rings and jets in the regions around a pulsar, like the one in the Crab Nebula supernova remnant.

For more information see:
http://nasascience.nasa.gov/about-us/smd-programs/physics-of-the-cosmos

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Plans For FY 2010

Herschel and Planck are scheduled to launch in May 2009 and will be in full science operations by FY 2010.

The Fermi Gamma Ray Space Telescope will continue in its prime operations phase. LISA, IXO and JDEM will continue low level technology development while awaiting final results of the Astrophysics decadal survey.

Project Descriptions and Explanation of Changes

Other Missions and Data Analysis

-The Herschel Space Observatory is a collaborative mission with the European Space Agency and is scheduled for a May 2009 launch. It has the largest single mirror ever built for a space telescope and it will collect long-wavelength radiation from some of the coldest and most distant objects in the universe. NASA has contributed to instruments onboard Herschel and will also host U.S. astronomer access to data through the NASA Herschel Science Center.

-Planck is also an ESA-led mission, with substantial NASA contributions, scheduled for launch in May, 2009. It will reveal the geometry and contents of the universe, how the universe grew immediately after its birth, and how the stage was set for the universe to evolve into structures that are seen today, such as galaxies. It will provide an order of magnitude increased precision in its measurement of the Cosmic Microwave Background (CMB).

-Fermi Gamma-ray Space Telescope is a joint NASA/DOE mission formerly called GLAST. Fermi launched June, 2008 and is currently in operational phase. It is designed to detect the highest energy gamma-rays ever measured in a space-based mission and will provide a full-sky map filled with thousands of gamma-ray sources, increasing the current tally by orders of magnitude.

-Chandra, a flagship X-ray observatory currently in extended operations, has allowed scientists to image complex systems in exquisite detail, and to determine the positions of thousands of distant X-ray sources. Chandra has also provided unique information on diverse subjects ranging from the presence and amount of dark matter in the universe to phenomena occurring near the horizons of black holes. Chandra ranked second in the FY 2008 Astrophysics Senior Review.

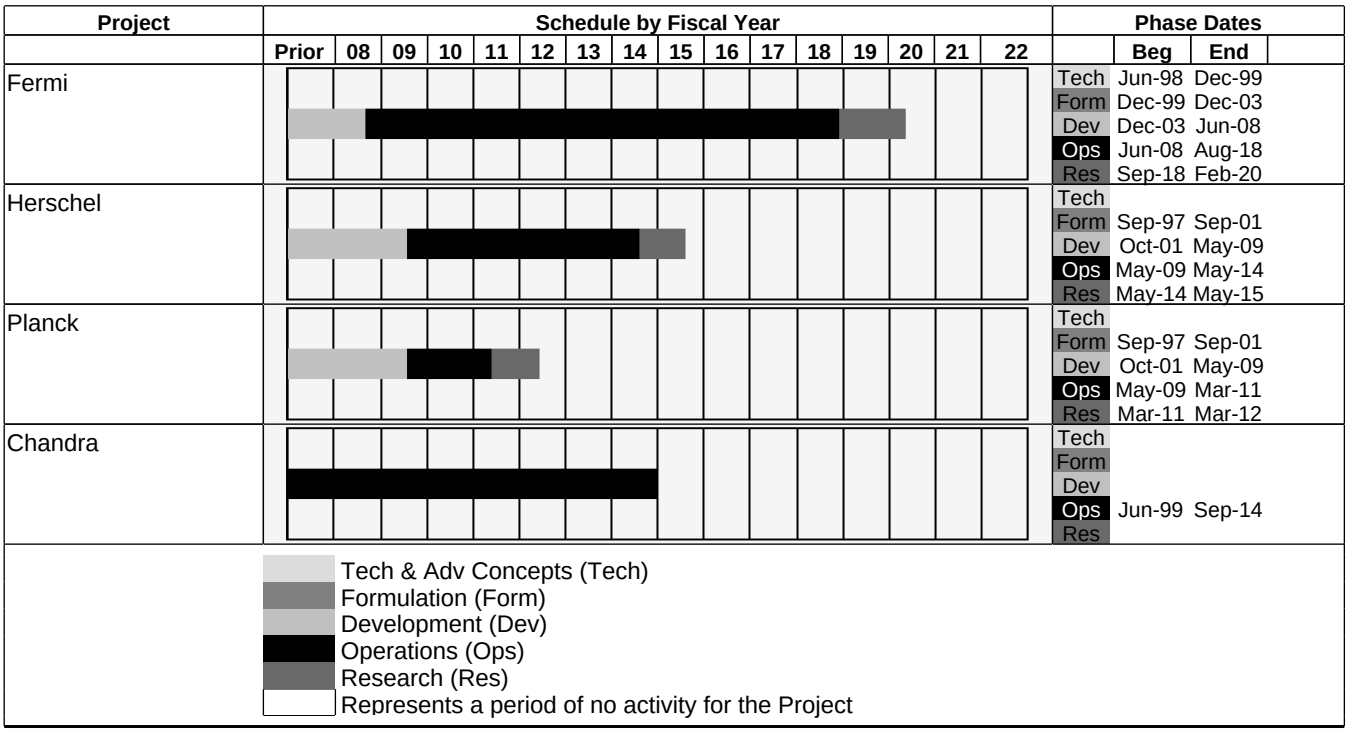
-The Laser Interferometer Space Antenna (LISA) is currently doing low level technology development through 2010 when the results of the Astrophysics decadal survey will be known. LISA, a joint mission with the European Space Agency, will provide a first view of the gravitational radiation spectrum from space, enabling scientists to "see" in new ways how the universe evolved, and allowing powerful new tests of fundamental laws.

-The International X-ray Observatory (IXO), formerly Constellation-X, is currently in pre-formulation doing low level technology development through 2010 when the results of the Astrophysics decadal survey will be known. It is a joint X-ray observatory with participation from NASA, the European Space Agency (ESA) and the Japanese Aerospace Exploration Agency (JAXA). Science objectives are the study of black holes and matter under extreme conditions, and the life cycles of matter and energy in the universe.

-The Joint Dark Energy Mission (JDEM), currently in pre-Phase A, is a space-based observatory that will make precision cosmological observations to measure the effects of dark energy on the recent expansion history of the universe and on the growth of structure in the universe.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Physics of the Cosmos

Implementation Schedule



Program Management

Goddard Space Flight Center has Program management responsibility. Project management is as follows:

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Fermi	GSFC	GSFC	Japan, Italy, France, Sweden, and Germany
Herschel (Instrumentation)	JPL	JPL	ESA
Planck (Instrumentation)	JPL	JPL	ESA
JDEM	GSFC	TBD	TBD
LISA	GSFC	GSFC/JPL	ESA
IXO	GSFC	GSFC	JAXA and ESA
Chandra	MSFC	None	None

Acquisition Strategy

The acquisition strategies for JDEM, IXO, and LISA are under development. NASA will seek to maximize the amount of competition to ensure that the best concepts and science are supported.

U.S. elements for the Herschel and Planck missions have been delivered to ESA.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**156.7**	**68.1**	**46.2**	**57.3**	**86.9**	**123.5**	**167.3**
Other Missions and Data Analysis	**156.7**	**68.1**	**46.2**	**57.3**	**86.9**	**123.5**	**167.3**
FY 2009 President's Budget Request	**162.6**	**48.1**	**67.7**	**68.4**	**96.4**	**126.2**	**--**
Other Missions and Data Analysis	**162.6**	**48.1**	**67.7**	**68.4**	**96.4**	**126.2**	**--**
Changes from FY 2009 Request	**-5.9**	**20.0**	**-21.5**	**-11.1**	**-9.5**	**-2.7**	**--**

Program Overview

Today we stand on the threshold of a voyage of unprecedented scope and ambition, promising insight into one of humankind's most timeless questions: Are we alone? One of the most exciting new fields of research within the NASA Astrophysics portfolio is the search for planets, particularly Earth-like planets, around other stars. During the last 15 years, astronomers have discovered over 300 planets orbiting nearby stars. Most of these planets were found using ground-based telescopes, and most of them are gas or ice giants, similar to the four outer planets in our own Solar System. The majority of these planets orbit much closer to their parent stars than do the giant planets in our system, some as close as 0.04 AU (1 AU = 1 astronomical unit = mean Earth-Sun distance, 93 million miles). Mercury, by comparison, orbits the Sun at a distance of about 0.4 AU (about 37 million miles).

Most of the known extrasolar planets have been discovered by the radial velocity, or the Doppler method, in which one measures the tiny back-and-forth motion of a star as a planet orbits around it. The Doppler method tends to favor the detection of massive planets since the greater the mass of the planet, the greater the "wobble" it induces in the parent star. Approximately thirty planets have been found using a second technique, the transit method, in which one measures the slight dimming of a star's light that occurs as a planet passes in front of it. The transit method only works on systems in which the planet's orbital plane is nearly parallel to one's line of sight. The Kepler mission is specifically designed to survey our region of the Milky Way galaxy to discover hundreds of Earth-size and smaller planets using the transit method to determine how many of the billions of stars in our galaxy have such planets.

In the future, through the use of astrometry, precision interferometry and eventually direct detection, NASA plans to embark on a series of missions designed to detect and characterize Earth-sized planets that are orbiting in the "habitable zone" of nearby stars (the range of distances at which liquid water could be stable at the planet's surface). The Agency's long-term vision for exoplanet exploration includes missions optimized not only to detect extrasolar planets, but also to measure their characteristics.

For more information, please see: http://exep.jpl.nasa.gov/

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

Plans For FY 2010

The Exoplanet Exploration Program (EXEP) will assess different techniques and mission concepts for detecting and characterizing extrasolar planets, including space-based astrometric, coronagraphic, and statistical concepts.

The Space Interferometry Mission (SIM) continues technology development pending results of the 2010 decadal survey.

Keck Interferometer development is complete and the interferometer is operational. Operations have been turned over to the California Association for Research in Astronomy (CARA). By early FY 2010, the interferometer Key Science program characterization of dust levels around nearby sun-like stars will be completed, helping to assess the level of impact on future exoplanet characterization missions.

Kepler launched on March 6, 2009, and by 2010 the mission will be in full operations phase.

Project Descriptions and Explanation of Changes

Other Missions and Data Analysis

This line item contains the following projects:

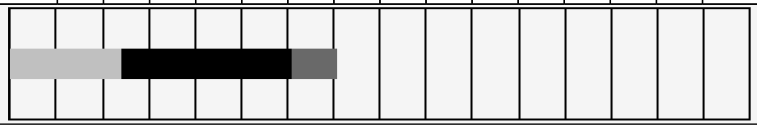
-Kepler launched in March 2009 and is finishing in-orbit checkout; the operations phase will begin in summer 2009. It is specifically designed to survey the distant stars in our region of the Milky Way galaxy to detect and characterize hundreds of Earth-size and smaller planets in or near the "habitable zone." The habitable zone encompasses the distances from a star where liquid water can exist on a planet's surface.

-Keck Operations is the NASA portion of the Keck Observatory partnership. NASA uses its share of observing time for support of Exoplanet and other astrophysics related science. Observation time is competed time, organized through the Exoplanet Exploration SR&T project.

-SIM is a mission under study in support of NASA's goal of searching for habitable planets. The project is currently doing risk reduction engineering, and is studying alternate designs over a range of cost and performance levels in support of the next Astrophysics decadal survey.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Exoplanet Exploration

Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22		Beg	End
Kepler																	Tech		
																	Form	Dec-01	May-05
																	Dev	May-05	Mar-09
																	Ops	Mar-09	Nov-12
																	Res	Nov-12	Nov-13

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Program Management

The Jet Propulsion Laboratory is resposible for program management.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Kepler	JPL (Development) & ARC (MO&DA)	JPL (Development) & ARC (MO&DA)	None
SIM	JPL	JPL	None

Acquisition Strategy

All major acquisitions for Kepler are in place. Ames Research Center and Ball Aerospace & Technologies (Boulder, CO) were selected as the Kepler development and operations team via a competative NASA Discovery Program Announcement of Opportunity. The Laboratory for Atmospheric and Space Physics (Boulder, CO) was chosen as a subcontractor for mission operations.

The acquisition strategy for the next Exoplanet mission is not yet determined. NASA will seek to use merit-based review as the basis for determining mission content to ensure that the best science and implementation strategy are supported.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Exoplanet Task Force	01/2008	Determine planet-finding research and technology approach & prioritization leading up to the next decadal survey. Report and recommended strategy published and sent to respective agencies. For more information, please see: http://nasascience.nasa.gov/about-us/NAC-subcommittees/nac-documents/2008-01_APS_ExoPTF.pdf	N/A
Performance	SRB	New	Program Assessment	2010

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Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	117.7	130.7	107.9	69.5	26.6	10.4	1.7
Wide - Field Infrared Survey Explorer (WISE)	72.7	65.2	13.0	5.2	1.6	0.2	0.0
Nuclear Spectroscopic Telescope Array (NuStar)	16.7	38.7	59.9	33.7	6.8	6.4	0.0
Other Missions and Data Analysis	28.3	26.8	35.0	30.6	18.2	3.8	1.7
FY 2009 President's Budget Request	106.4	130.6	93.3	43.3	11.7	6.4	--
Wide - Field Infrared Survey Explorer (WISE)	71.8	65.2	13.0	5.2	1.6	0.0	--
Nuclear Spectroscopic Telescope Array (NuStar)	0.0	41.5	57.8	31.0	6.8	6.4	--
Other Missions and Data Analysis	34.6	23.9	22.5	7.1	3.2	0.0	--
Changes from FY 2009 Request	11.3	0.1	14.5	26.2	15.0	4.0	--

Note: Astrophysics Explorer budget has increased due to the addition of the recently selected Astro-H/SXS Mission of Opportunity. FY 2010 President's Budget Request is understated by $9.9M due to the transfer of Astro-H from Heliophysics Explorer to Astrophysics Explorer Program in FY2010.

Program Overview

The Explorer Program provides frequent flight opportunities for world-class astrophysics and space physics investigations, using an innovative and efficient approach to spacecraft development and operations. The program is composed of a series of independent space science missions that share a common funding and management structure. The program emphasizes missions that can be accomplished under the control of the scientific research community within specified life cycle cost requirements. The program provides access to space and launch vehicle funding. These funds are part of the total cost cap for each mission.

The Wide-field Infrared Survey Explorer (WISE) is the only Astrophysics Explorer mission currently in development. The Nuclear Spectroscopic Telescope Array (NuSTAR) and Astro-H missions are in formulation. Astro-H is a Mission of Opportunity selected in 2008; the mission will be led by Japan, with NASA's contribution being a Soft X-ray Spectrometer (SXS). Please refer to the Heliophysics Theme for information on additional Explorer projects. For more information, visit: http://explorers.gsfc.nasa.gov.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Plans For FY 2010

The WISE launch, and the start of prime operations are scheduled for FY 2010. Dependent upon cryogen life, the mission may be extended beyond its seven month baseline.

The Nuclear Spectroscopic Telescope Array (NuSTAR) mission will hold its confirmation review in August 2009 in preparation to enter the development phase in FY 2010.

The SXS instrument for Astro-H is scheduled to be in the development phase by FY 2010, as the mission is scheduled to have a preliminary design review and a critical design review in FY 2010.

Suzaku will enter its fifth year of operations and its second year of key project observations. Key projects are defined as comprehensive observing programs sampling a number of objects of a particular class, or surveying a large region of the sky, in order to take maximal advantage of the unique attributes of Suzaku to address important astrophysical problems.

Swift will continue to in its extended operations phase, per results of the most recent Senior Review.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Project Descriptions and Explanation of Changes

Wide-field Infrared Survey Explorer (WISE)

Currently in development and planned for launch in 2009, the Wide-field Infrared Survey Explorer (WISE) will provide an all-sky survey of galaxies in the infrared. During its six-month mission, WISE will map the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe. WISE's infrared survey will provide an essential catalog for the James Webb Space Telescope. As the telescope orbits from the North Pole to the South Pole and then back up to the North Pole, it will sweep out a circle in the sky. As Earth moves around the Sun, this circle will shift, until WISE has observed the entire sky.

Nuclear Spectroscopic Telescope Array (NuSTAR)

The Nuclear Spectroscopic Telescope Array (NuSTAR), currently in formulation, is planned for launch in August 2011. NuSTAR will provide a greater capability for using high-energy X-rays to detect black holes than any currently existing instrument. NuSTAR has been designed to answer fundamental questions about the universe, such as: How are black holes distributed through the cosmos? How were the elements of the universe created? What powers the most extreme active galaxies? This mission will expand the ability to understand the origin of cosmic rays and help predict the destinies of stars and galaxies.

Other Missions and Data Analysis

Included in this line item are five operating spacecraft in their extended operations phase:

-Suzaku is Japan's fifth X-ray astronomy mission, on which NASA provided the five X-ray mirrors, as well as one instrument: the micro-calorimeter spectrometer. Suzaku studies black holes, neutron stars, and quasars, to unravel the physics of high-energy processes and the behavior of matter under extreme conditions.

-Swift studies the position, brightness, and physical properties of gamma-ray bursts. Within seconds of detecting a burst, Swift relays a burst's location to ground stations, allowing both groundbased and space-based telescopes around the world the opportunity to observe the burst's afterglow.

-The Galaxy Evolution Explorer (GALEX) is exploring the origin and evolution of galaxies, the origins of stars and heavy elements, and is conducting an all-sky ultraviolet survey.

-The Wilkinson Microwave Anisotropy Probe (WMAP), studies the early universe by measuring the cosmic microwave background radiation over the full sky. WMAP produced the earliest "baby picture" of the universe, showing temperature variation of microwave light 379,000 years after the big bang, over 13 billion years ago.

-Rossi X-Ray Timing Explorer (RXTE) observes the high-energy worlds of black holes, neutron stars, and X-ray pulsars, gathering important information about processes and structures in white-dwarf stars, X-ray binaries, neutron stars, pulsars, and black holes.

Also included in this line item is the new Mission of Opportunity, Astro-H, which is an X-ray observation satellite under development by JAXA. With a 2013 launch, the mission objectives are to: trace the growth history of the largest structures in the universe, provide insights into the behavior of material in extreme gravitational fields, determine the spin of black holes and the equation of state of neutron stars, trace shock acceleration structures in clusters of galaxies, and investigate the detailed physics of jets. NASA is participating in this mission by providing the High-Resolution Soft X-Ray Spectrometer (SXS) instrument.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Implementation Schedule

Project	Schedule by Fiscal Year																Phase Dates		
	Prior	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22		Beg	End
WISE																	Tech		
																	Form	Apr-02	Oct-06
																	Dev	Oct-06	Nov-09
																	Ops	Nov-09	May-10
																	Res	May-10	May-13
Swift																	Tech		
																	Form		
																	Dev		
																	Ops	Apr-04	Sep-12
																	Res		
Suzaku																	Tech		
																	Form		
																	Dev		
																	Ops	May-05	Sep-11
																	Res		
WMAP																	Tech		
																	Form		
																	Dev		
																	Ops	Jun-01	Sep-11
																	Res		
GALEX																	Tech		
																	Form		
																	Dev		
																	Ops	Apr-03	Sep-12
																	Res		
RXTE																	Tech		
																	Form		
																	Dev		
																	Ops	Dec-95	Sep-10
																	Res		
NuSTAR																	Tech		
																	Form	Feb-08	Nov-09
																	Dev	Nov-09	Aug-11
																	Ops	Aug-11	Sep-13
																	Res		
Astro-H																	Tech		
																	Form	Jun-08	Aug-09
																	Dev	Aug-09	Aug-13
																	Ops	Aug-13	Aug-15
																	Res		

Tech & Adv Concepts (Tech)
Formulation (Form)
Development (Dev)
Operations (Ops)
Research (Res)
Represents a period of no activity for the Project

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer

Program Management

The Astrophysics Explorer Program is a multiple-project program with program responsibility assigned to Goddard Space Flight Center (GSFC).

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
WISE	GSFC	JPL	None.
GALEX	GSFC	N/A	None.
NuSTAR	GSFC	JPL	None.
Astro-H	GSFC	N/A	None.
Swift	GSFC	N/A	None.
Suzaku	GSFC	N/A	None.
WMAP	GSFC	N/A	None.
RXTE	GSFC	N/A	None.

Acquisition Strategy

Explorer projects are selected through competitive Announcements of Opportunity, from which multiple investigations are selected for initial concept studies, followed by a competitive down-select to proceed to the next stage of formulation. Investigations are selected to proceed from one phase to the next through execution of contract options, based on successful technical, cost, and schedule performance in the previous phases.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Wide-Field Infrared Survey Explorer

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**152.5**	**72.7**	**65.2**	**13.0**	**5.2**	**1.6**	**0.2**	**0.0**	**0.0**	**310.5**
Formulation	96.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	96.6
Development / Implementation	55.9	72.7	65.2	0.0	0.0	0.0	0.0	0.0	0.0	193.8
Operations / Close-out	0.0	0.0	0.0	13.0	5.2	1.6	0.2	0.0	0.0	20.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
FY 2009 President's Budget Request	**153.7**	**71.8**	**65.2**	**13.0**	**5.2**	**1.6**	**0.0**	**--**	**0.0**	**310.5**
Formulation	96.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	96.6
Development / Implementation	57.1	71.8	65.2	0.0	0.0	0.0	0.0	--	0.0	194.1
Operations / Close-out	0.0	0.0	0.0	13.0	5.2	1.6	0.0	--	0.0	19.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	**-1.2**	**0.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**--**	**0.0**	**0.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	-1.2	0.9	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.3
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.2	--	0.0	0.2
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.1

Note: The FY 2010 LCC number in the table above is understated by $4M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of NASA's Initial Operating Plan for FY 2009, the estimated lifecycle cost of WISE will be $314.5M, and the estimated Development cost will be $197.8M.

Explanation of Project Changes

Although only minor changes are seen in the table above, NASA's Initial Operating Plan for FY 2009 requests an increase of $4.0M for additional testing of the spacecraft, reducing risk for the November 2009 launch.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Wide-Field Infrared Survey Explorer

Project Purpose

The Wide-Field Infrared Survey Explorer (WISE) mission has six objectives: finding the most luminous galaxies in the universe; finding the closest stars to the Sun; detecting most main-belt asteroids larger than three kilometers; extending the 2MASS Project survey into the thermal infrared; enabling a wide variety of studies ranging from the evolution of protoplanetary debris disks to the history of star formation in normal galaxies; and providing a catalog for the James Webb Space Telescope.

For more information see: http://wise.ssl.berkeley.edu/

Project Parameters

The single WISE instrument is a four-channel imager that will take overlapping snapshots of the sky. WISE includes: a two-stage, solid-hydrogen cryostat to cool detectors and optics; a 40-centimeter telescope and reimaging optics; and a scan mirror to stabilize the line-of-sight while the spacecraft scans the sky.

Project Commitments

WISE will launch in November 2009 on a six-month mission (with a one-month checkout) to provide an all-sky survey in the wavelengths from 3.5 to 23 microns--up to 1000 times more sensitive than the Infrared Astronomical Satellite (IRAS) survey.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Spacecraft	Ball Aerospace & Technologies Corporation (BATC)	40-centimeter telescope	Same	Same
Launch Vehicle	United Launch Alliance (ULA)	Delta 2	Same	Same
Science Payload	Space Dynamics Laboratory (SDL)	Instrument integration and launch support	Same	Same
Mission Operations and Data Management	UCLA	Management of the data and mission operations	Same	Same

Schedule Commitments

WISE entered development in October 2006 after an extended formulation phase. WISE is scheduled to launch in November 2009.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
Begin Development	October 2006	October 2006	Same
Assembly, Test & Launch Operations	April 2009	April 2009	Same
Launch Readiness	November 2009	November 2009	Same

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Wide-Field Infrared Survey Explorer

Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Wide-Field Infrared Survey Explorer	2007	192.1	2009	197.8	3	Launch Readiness	11/30/2009	11/30/2009	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**192.1**	**197.8**	**5.7**
I & T Systems	5.3	4.7	-0.6
Technology Development	3.4	3.0	-0.4
Aircraft/Spacecraft	37.8	37.4	-0.4
Ground Systems	13.6	11.9	-1.7
Launch Vehicle	87.5	76.9	-10.6
Other	16.5	36.1	19.6
Payload	23.0	23.4	0.4
Science/Technology	5.0	4.4	-0.6

Project Management

The Jet Propulsion Laboratory is responsible for project management.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	JPL	None	None
Mission operations and data analysis	JPL	JPL	None
Payload	JPL	None	None

Acquisition Strategy

The Wide-field Infrared Survey Explorer was selected competitively as part of the Explorer Announcement of Opportunity in 2002. All elements of the project were included in the competitive proposal. The cryogenic instrument is being built by Space Dynamics Laboratory (Logan, UT); Ball Aerospace and Technologies Corporation (Boulder, CO) is building the spacecraft; University of California, Los Angeles (Los Angeles, CA) is managing the mission operations and data center; and United Launch Alliance (Denver, CO) is providing the launch vehicle.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Development:	Wide-Field Infrared Survey Explorer

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Standing Review Board (SRB)	11/2008	The System Integration Review (SIR) evaluated the readiness of the project to start flight system assembly, test, and launch operations. The WISE project passed the SIR.	N/A
Quality	Standing Review Board (SRB)	N/A	The Operations Readiness Review examines the actual system characteristics and the procedures used in the system's operation and ensure that all system and support (flight or ground) hardware, software, personnel, and procedures are ready for operations and that user documentation accurately reflects the deployed state of the system.	9/2009
Quality	Standing Review Board (SRB)	N/A	The Flight Readiness Review examines tests, demonstrations, analyses, and audits that determine the system's readiness for a safe and successful flight/launch and the subsequent flight operations.	10/2009

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Cover deployment reliability	Premature deployment of the WISE cover could result in venting of the cryogen and loss of the mission. Failure to deploy would block light from entering the telescope and would also result in loss of the mission.	Cover deployment actuation circuitry has been reviewed with great care and includes components with extensive flight heritage. End-to-end testing and monitoring will be conducted during spacecraft level ground testing.
Hydrogen cryostat safety	The cryogen for the WISE cryostat is solid hydrogen. Operational errors could result in an explosion.	The WISE hardware and work procedures are designed with safety foremost in mind. Risk has been mitigated through careful design, review, training, and practice.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Nuclear Spectroscopic Telescope Array

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	16.7	38.7	59.9	33.7	6.8	6.4	0.0
FY 2009 President's Budget Request	0.0	41.5	57.8	31.0	6.8	6.4	--
Total Change from 2009 President's Budget Request	16.7	-2.8	2.1	2.7	0.0	0.0	--

Project Purpose

The Nuclear Spectroscopic Telescope Array (NuSTAR) is an Explorer mission currently planned for an August 2011 launch. NuSTAR, unlike Chandra and XMM-Newton, will observe the universe at high X-ray energy levels. By focusing higher energy X-rays, NuSTAR will start to answer several fundamental questions about the universe including: How are black holes distributed through the cosmos? How were heavy elements forged in the explosions of massive stars? What powers the most extreme active galaxies?

NuSTAR's primary science goal is to make the first deep observations of regions of the sky in the high energy X-ray band (6-79 keV) in order to locate massive black holes in other galaxies, locate and examine the remnants of collapsed stars in our galaxy, observe selected very high energy gamma-ray sources, and observe any supernovae of opportunity in the local group of galaxies. NuSTAR's key science products will be sensitive high-energy X-ray survey maps of the celestial sky that will guide the X-ray astronomy community research for several years to come.

For more information see: http://www.nustar.caltech.edu/

Project Preliminary Parameters

NuSTAR will image the sky in the high energy X-ray band (6-79 KeV) and the spacecraft will be 3-axis stabilized. The primary science instruments will be two identical focusing X-ray telescopes which utilize an extendable 10-meter mast. The launch vehicle will be a Pegasus XL.

Mission Directorate:	Science
Theme:	Astrophysics
Program:	Astrophysics Explorer
Project In Formulation:	Nuclear Spectroscopic Telescope Array

Estimated Project Deliverables

NuSTAR will be launched in August 2011 into a 550km circular orbit around the Earth, with an orbital inclination currently planned in the 5-27 degree range. Prime operations phase is two years. No extended mission is currently budgeted.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Spacecraft	Orbital Sciences Corporation	Spacecraft design, fabrication and testing.		Same
Mission operations ,focal plane assembly and instrument electronics	University of California, Berkeley	Aperture stop, active shield module and mechanical enclosures		Same
X-ray optics development	Columbia University, GSFC and the Danish Technical University	Overall optics assembly management and manufacturing		Same
Mast, canister and instrument structure	ATK	Delivery of mast, canister and instrument structure for the spacecraft		Same

Estimated Project Schedule

NuSTAR was authorized for mission re-start in September 2007 and was authorized to proceed into Phase B in January 2008. Confirmation to proceed into Phase C (implementation) is planned for August 2009.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Formulation			
Preliminary Design Review			January 2008
Confirmation Review			August 2009
Launch			August 2011

Mission Directorate:	Science
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Project Management

The Jet Propulsion Laboratory is responsible for NuSTAR Project Management.

The Principal Investigator at the California Institute of Technology is responsible for mission science.

Acquisition Strategy

NuSTAR was selected via a NASA Explorers Announcement of Opportunity.

The spacecraft is being developed by Orbital Sciences Corporation (OSC) in Dulles, Virginia.

X-ray optics are being developed by Columbia University (NY), GSFC (MD), and the Danish Technical University.

Alliant Techsystems (ATK, Goleta, CA) is responsible for mission mast and structure. The California Institute of Technology and UC Berkeley are completing the focal plane assembly and electronics.

JPL is responsible for overall instrument integration, and OSC is completing overall observatory integration. Caltech is responsible for science and UC Berkeley is responsible for mission operations.

Launch vehicle acquisition is through KSC.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	07/2008	SRR Authority to enter Phase B	N/A
Performance	SRB	N/A	Preliminary Design Review (PDR); authority to enter Phase C	06/2009

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