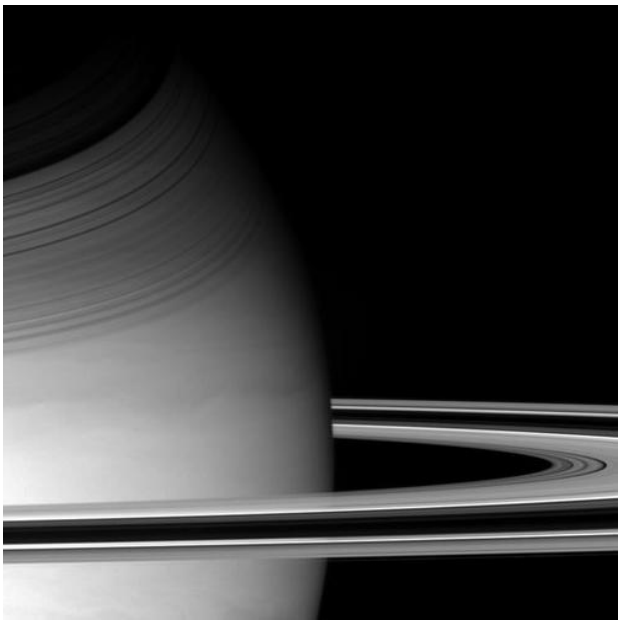
Appropriation Summary: Science, Aeronautics and Exploration

Millions of Dollars	FY 2004 9/28/04 Operating Plan	FY 2005 12/23/04 Operating Plan	FY 2006 Budget Request
SCIENCE	**5,599.8**	**5,527.2**	**5,476.3**
Solar System Exploration	1,909.5	1,858.1	1,900.5
The Universe	1,351.7	1,513.2	1,512.2
Earth-Sun System	2,338.6	2,155.8	2,063.6
EXPLORATION SYSTEMS	**2,573.7**	**2,684.6**	**3,165.4**
Constellation Systems	911.5	526.5	1,120.1
Exploration Systems Research and Technology	676.6	695.6	919.2
Prometheus Nuclear Systems and Technology	0.0	431.7	319.6
Human Systems Research and Technology	985.6	1,030.8	806.5
AERONAUTICS RESEARCH	**1,056.8**	**906.2**	**852.3**
Aeronautics Technology	1,056.8	906.2	852.3
EDUCATION	**230.4**	**216.7**	**166.9**
Education Programs	230.4	216.7	166.9
TOTAL APPROPRIATION	**9,460.7**	**9,334.7**	**9,661.0**



The Cassini spacecraft captured this sidelong view of Saturn's rings at it pierced the ring plane on December 14, 2004. Saturn's tilt relative to the Sun throws dramatic shadows of the rings onto the planet's northern hemisphere. Details in Saturn's swirling atmosphere are also visible.

Themes

Solar System Exploration

The Universe

Earth-Sun System

SCIENCE

Purpose

The newly organized Science Mission Directorate (SMD) (see Table 1 below) engages the Nation's science community, sponsors scientific research, and develops and deploys satellites and probes in collaboration with NASA's partners around the world to answer fundamental questions requiring the view from and into space. SMD seeks to understand the origins, evolution, and destiny of the universe and to understand the nature of the strange phenomena that shape it. SMD seeks to understand the nature of life in the universe and what kinds of life may exist beyond Earth. SMD seeks to understand the solar system, both scientifically and in preparation for human exploration. SMD also seeks to understand the Sun and Earth, changes in the Earth-Sun system, and the consequences of the Sun-Earth relationship for life on Earth.

Table 1: Crosswalk between old and new NASA Science organizations

Previous Science Enterprises and Themes	Science Mission Directorate
Space Science Enterprise	Solar System Exploration Theme
Solar System Exploration	
Mars Exploration	
Lunar Exploration	
Astronomical Search for Origins	The Universe Theme
Structure and Evolution of the Universe	
Sun-Earth Connections	Earth-Sun System Theme
Earth Science Enterprise	
Earth System Science	
Earth Science Applications	

The Science Mission Directorate also is an integral component of the Vision for Space Exploration through its sponsorship of research that both enables, and is enabled by, NASA's exploration activities. The SMD portfolio contributes to realization of the Vision by striving to:

- *Understand the history of Mars and the formation our solar system.* By understanding the formation of diverse terrestrial planets (with atmospheres) in the solar system, researchers learn more about the Earth's future and the most promising opportunities for habitation beyond our planet. For example, differences in the impacts of collisional processes on Earth, the Moon, and Mars can provide clues about differences in origin and evolution of each of these bodies.
- *Search for Earth-like planets and habitable environments around other stars*. SMD pursues multiple research strategies with the goal of developing effective astronomically detectable signatures of biological processes. The study of the Earth-Sun system may help researchers identify atmospheric biosignatures that distinguish Earth-like (and potentially habitable) planets around nearby stars. An understanding of the origin of life and the time evolution of the atmosphere on Earth may reveal likely signatures of life on extrasolar planets.
- *Explore the solar system for scientific purposes and to support human exploration*. In order to support safe human travel and, ultimately, a sustained presence by both robots and humans, SMD is establishing interdisciplinary scientific research focus areas to develop diagnostic and predictive methods and models for assessing the conditions of the interplanetary medium. For example, large-scale coronal mass ejections from the Sun can cause potentially lethal consequences for improperly shielded human flight systems, as well as some types of robotic systems.

In recent years, NASA science missions and research have returned spectacular and important results. Space observations have played a central role in these fascinating discoveries. From its activities directly supporting the Vision, to its investigations of the structures and processes at work in the universe, to studies of Earth, NASA's Science Mission Directorate expects to continue to build upon its past successes.

FY 2004 Accomplishments

On June 30 2004, Cassini and the Huygens probe successfully became the first spacecraft to orbit Saturn. That ride into Saturn's orbit brought Cassini closer to the rings than it will ever be again and resulted in the most detailed pictures of the rings ever seen. The sounds of Cassini's trip through the rings were recorded by the spacecraft's radio and plasma wave science instrument. Cassini's first very close flyby of Saturn's moon Titan occurred on October 26, 2004, and produced an impressively detailed view of this mysterious moon.

Spirit and Opportunity landed on Mars successfully and continue to provide amazing science data and images to the science community and the public. For calendar year 2004, Spirit, which landed on Mars on January 4, 2004, traversed 4 kilometers of Martian landscape, while Opportunity has traversed 2 kilometers since landing on January 24, 2004. Both rovers continue to perform exceptionally, far exceeding their original design life of 90 Martian days.

Gravity Probe B (GP-B) launched on April 20, 2004. GP-B has been collecting science data for 20 weeks, and is close to half way through the science phase of the mission. The data collection process is continuing to proceed smoothly, and the quality of the data remains excellent.

In August 2004, Chandra completed five years of contributions to the understanding of black holes. It also observed, for the first time, two super-massive black holes in the same galaxy, galactic monsters that are destined for a dramatic collision.

The Solar and Heliospheric Observatory (SOHO), launched in December 1995, sends daily thrilling images from which research scientists and the public learn about the Sun's nature and behavior. During the last year, SOHO recorded the most powerful coronal mass ejections since operation.

The Mercury Surface, Space Environment, Geochemistry, and Ranging spacecraft (MESSENGER), launched August 3 2004, started a 4.9-billion mile (7.9-billion kilometer) journey towards Mercury. MESSENGER's suite of instruments will investigate Mercury's composition, image its surface in color, map its magnetic field, measure the properties of its core, explore the mysterious polar deposits, and characterize Mercury's tenuous atmosphere and Earth-like magnetosphere.

Stardust, NASA's first dedicated sample return mission to a comet, successfully navigated through the particle- and gas-laden coma around comet Wild 2 in January 2004. During the hazardous traverse, the spacecraft flew within 240 kilometers (149 miles) of the comet, catching samples of comet particles and capturing detailed pictures of Wild 2's pockmarked surface. The collected particles will be returned to Earth for in-depth analysis on January 15, 2006.

Aura, launched July 15, 2004, completes the first series of the Earth Observing System (EOS). Aura's view of the atmosphere and its chemistry will complement the global data already being collected on the oceans, land cover, ice sheets, and solar irradiance by NASA's other EOS satellites. Currently, the spacecraft is providing the first daily, direct global measurements of low-level ozone and many other pollutants affecting air quality.

The twin Gravity Recovery And Climate Experiment (GRACE) satellites demonstrated the ability to measure variability in the water quantity of continental underground reservoirs, where most of Earth's liquid fresh water is stored.

NASA, in collaboration with the United States Geological Survey, has sponsored the development of the Rundle/Tiampo earthquake forecasting algorithm that identifies small geographic zones of high earthquake risk in California. Thirteen of the last 14 earthquakes greater than magnitude 5 have occurred within these narrowly defined hotspots. This research and the resulting forecasting tools are critical to establishing successful Tsunami warning systems in the future.

Theme Distribution

Budget Authority ($ in millions)	FY 2004	FY 2005	FY 2006
Solar System Exploration	1910	1858	1901
The Universe	1352	1513	1512
Earth-Sun System	2339	2156	2064
Total	5601	5527	5477

Note: For all formats, the FY 2004 column reflects the FY 2004 Congressional Operating Plan, dated 9/28/2004. The FY 2005 column reflects the FY 2005 Congressional Operating Plan, dated 12/23/2004. The FY 2006 column represents the FY 2006 President's Budget Submit.

Solar System Exploration

People have been watching planets, moons, and comets wander amongst the stars for millennia. Yet, it was always "look, don't touch" until 1969, when NASA sent two men to Earth's Moon--and they came back with lunar rock and soil for scientists to study. Since those first footsteps, NASA has broadened its reach with an increasingly sophisticated series of explorers that have landed on asteroids, tasted the swirling gases of Jupiter's atmosphere, and collected the breath of the Sun. Just in the past year, SMD has:

- Gathered nearly irrefutable evidence that Mars once had saltwater seas on its surface;
- Captured photographs of unknown moons and surprising textures hidden in Saturn's rings; and
- Listened in as the Voyager's daily reports sent back the sound of a solar blast wave.

In the next few decades, NASA intends to deepen understanding of the solar system, with spacecraft fanning out to destinations from the innermost planet to the very edge of the Sun's influence. Some spacecraft will stay in Earth's orbit, others will follow looping one-way trajectories through the gravitational forces of the planets, and a few will come back carrying scientifically priceless pieces of other worlds.

Overall Budget

The FY 2006 request is $1,901 M, or a $43 M or 2 percent increase from the FY 2005 budget:

- $136.9 M for launch and operation of New Horizons Pluto Kuiper Belt Mission, and Dawn.
- $257 M to continue deep-space mission support, including Cassini, Stardust, Genesis, and MESSENGER.
- $96 M for technology development of in-space propulsion and radioisotope power system development.
- $94 M for Phoenix full mission competition through an Announcement of Opportunity.
- $184 M for the conceptual development of the Mars Science Laboratory, a rover with an on-board laboratory.
- $105 M for the continued development of the Lunar Reconnaissance Orbiter.

The Universe

People have gazed at the stars, given them names, and observed their changes for thousands of years. NASA joined the ancient pursuit of knowledge of the universe comparatively recently. Nevertheless, in NASA's 40 years of space science, the Agency has contributed to several major advances in astronomy, including:

- Observations of an atmosphere of a planet outside the solar system.
- Completion of the first detailed full-sky map of the oldest light in the universe.
- Discovery that dark energy is accelerating the expansion of the universe.

Even so, NASA still has the most perplexing and important puzzles to solve:

- How did the universe begin?
- Does time have a beginning and an end?
- Where did we come from?
- Are we alone?

To answer these questions, NASA is planning a series of missions linked by powerful new technologies and complementary approaches to shared science goals. In the first few decades of this new century, astronomers will greatly advance the study of classical cosmology, the description of the universe on the largest scales and how it works. SMD also will begin to read the opening chapter of the story of galaxies, witnessing the actual birth of the stars within.

Overall Budget

The FY 2006 request is $1,512 M, or a $1 M decrease from the FY 2005 budget:

- $372 M to James Webb Space Telescope for a wide array of detailed flight design and long-lead procurement and flight hardware fabrication efforts.
- $191 M Hubble funding for operations and data analysis, life extension activities, development activities for a robotic deorbit spacecraft, as well as the modification and upkeep of ground operations systems.
- $109 M to progress the Space Interferometry Mission through the critical design phase of the project.
- $48 M to support operations readiness of Stratospheric Observatory for Infrared Astronomy (SOPHIA).

Earth-Sun System

NASA uses the unique vantage point of space to understand and explore Earth and the Sun. The relationship between the Sun and the Earth is at the heart of a complex, dynamic system that researchers do not yet fully understand. The Earth-Sun system, like the human body, is comprised of diverse components that interact in complex ways, requiring unique capabilities for characterizing, understanding, and predicting change. Therefore, researchers need to understand the Sun, the heliosphere, and Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system.

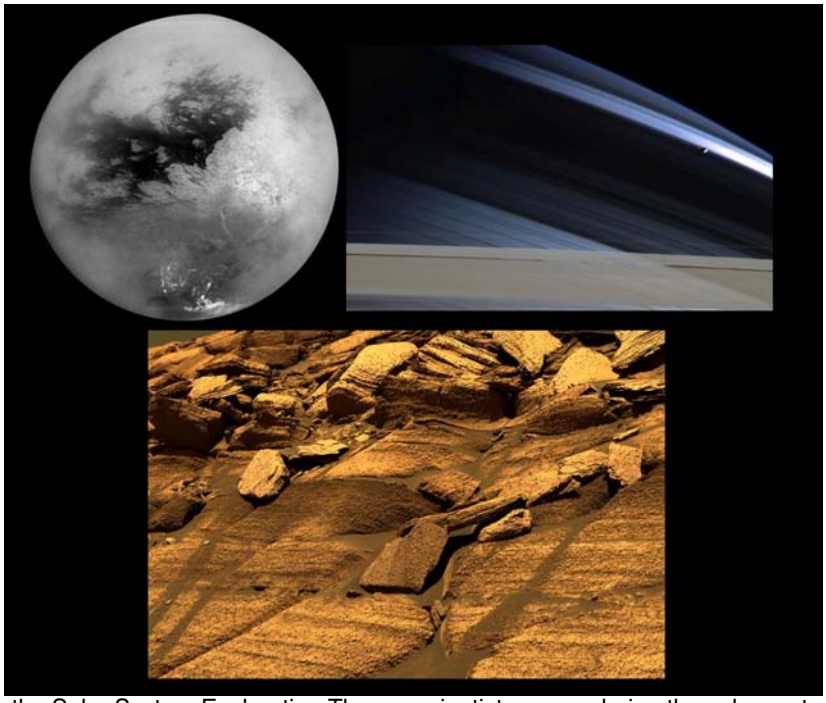
At the center of the solar system is the Sun, a magnetically variable star. This variability has impacts on life and technology that are felt here on Earth and throughout the solar system. NASA is working to understand this planetary system because it is the only star-planet system researchers can investigate in detail. Using NASA's view from space to study the Earth-Sun system, researchers also can better predict critical changes to Earth and its space environment.

Overall Budget

The FY 2006 request is $2064 M, a $92M or 4 percent decrease from the FY 2005 budget:

- $159 M for Solar Dynamics Observatory to complete integration and test of the spacecraft.
- $47.7 M for the launch and initial operations of the Solar Terrestrial Relations Observatory.
- $55.3 M for continued development through critical design and initial test of Aquarius, a satellite to measure global ocean surface salinity for the first time.
- $845 M for Earth Sun system research to support algorithm development and improvement and laboratory and field experiments to validate satellite-based observations.

Solar System Exploration



In the Solar System Exploration Theme, scientists are exploring the solar system to understand the origin and evolution of life, and to search for evidence of life elsewhere.

President's FY 2006 Budget Request (Dollars in Millions)

Solar System Exploration	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	1,909.5	1,858.1	1,900.5	2,347.7	2,831.9	2,999.0	3,066.2
Changes from FY 2005 Request	-1.5	-89.8	-160.4	-177.0	-122.8	-127.2	

Overview: *What* NASA Accomplishes through the Solar System Exploration Theme

The Solar System Exploration (SSE) Theme seeks to understand how the solar system formed and evolved, and whether there might be life in the solar system beyond Earth. This Theme is founded upon the pursuit of three simple yet profound questions: Where do we come from? What is our destiny? Are we alone? These overarching questions lead to more focused questions about our solar system: How do planets and their satellites form and how have they evolved over the lifetime of the solar system? How are the planets alike and how do they differ and why? What physical and chemical conditions and history must a planet have in order to be suitable for life? How were the ingredients for life, water and simple organic substances, brought to the inner terrestrial planets? Planets and satellites receiving special attention in the SSE Theme include Mars and the Moon. The Mars program determines the planet's physical, dynamical and geological characteristics, investigates the variability of the Martian climate in the context of understanding habitability, and investigates whether Mars ever harbored any kind of life. The Lunar program's main focus will be demonstrating capabilities to conduct sustained research on Mars as well as deeper and more advanced explorations of the solar system. Discovery and New Frontiers are competed and peer reviewed programs that give the scientific community the opportunity to assemble a team and design focused science investigations that complement other science explorations. Technology investments in propulsion and radioisotope power systems will reduce mission costs and increase capabilities for exploration and science return. The Research program provides new scientific understanding and instrumentation that enables the next generation of flight missions. DSMS provides capabilities and infrastructures for tracking, navigation, and data return to Earth to support interplanetary spacecraft missions.

Theme: Solar System Exploration

Relevance: *Why* NASA conducts Solar System Exploration work

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

The planets and satellites of the solar system and the ancient icy bodies far from the Sun are "Rosetta stones" that can tell unique stories about the evolution of the solar system. As researchers learn more about the origins of living systems on Earth and the solar system planets and moons, they may learn that life has arisen on some of them beyond Earth. In support of the Vision for Space Exploration, the robotic spacecraft dedicated to investigating these questions will serve as trailblazers for future human exploration. The solar system beyond low Earth orbit is a harsh and forbidding place of hot and cold extremes and fierce high-energy radiation. Before sending astronauts into this forbidding environment, NASA must have an adequate base of scientific knowledge and technological capability to protect them. Robotic spacecraft can endure this environment and prepare the way for humans. SSE robotic planetary programs such as the Voyagers, Galileo, Cassini, Mars, Discovery and others have been spectacularly successful and have vastly increased knowledge of the solar system. Knowledge gained from these and future robotic missions is essential as NASA prepares for a return to the moon and the eventual extension of human presence to Mars and beyond. Robotic exploration is an integral part of an overall strategy to extend human presence throughout the solar system.

Relevance to the NASA mission:

The SSE Theme supports NASA's mission to "explore the universe and search for life" by exploring the solar system, understanding the origin and evolution of life, and searching for evidence of life elsewhere.

Relevance to education and public benefits:

The SSE Theme strives to use its missions, research programs, and the human resources of the space science community to enhance the quality of American science, mathematics, and technology education, particularly at the pre-college level. SSE is dedicated to sharing the excitement of discoveries and knowledge generated by space science missions and research with the public, as well as contributing to the creation of the talented scientific and technical workforce needed for the 21st century.

Public benefits from SSE include a growing understanding of the solar system and Earth's significance within it. SSE's Discovery, Mars, Research, and Technology programs were among the first at NASA to require a plan for education and public outreach, as NASA recognized the importance of communicating the excitement of space exploration to the public.

Theme: Solar System Exploration

Performance

Major Activities Planned for FY 2006:

- Successfully return Stardust Discovery Mission science samples to Earth in January 2006.
- Successfully launch Dawn Discovery Mission by July 2006.
- Successfully achieve a major MESSENGER Discovery Mission milestone with the flyby of Venus (on the way to Mercury).
- Successfully launch New Horizons Pluto Kuiper Belt Mission in January 2006.
- Successfully insert the Mars Reconnaissance Orbiter into orbit around Mars and begin science investigations.

Major Recent Accomplishments:

- Cassini successfully arrived at Saturn and a Huygens Probe (ESA instrument) landed successfully on Titan on December 24, 2005. The probe and orbiter have generated unprecedented scientific results.
- Genesis had a less than perfect landing, but was able to return the sample of solar wind particles back to Earth. These particles are currently being analyzed at the curation lab.
- Spirit and Opportunity landed on Mars successfully and provided amazing science data and images to the science community and the public. The rovers' lifespans far exceed their designs (>300%).
- Deep Impact launched successfuly on January 12, 2004.
- Solar System Exploration (SSE) selected six science instruments for the Lunar Reconnaissance Orbiter mission.

Theme: Solar System Exploration

Solar System Exploration Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

1. Undertake robotic and human lunar exploration to further science and to develop and test new approaches, technologies, and systems to enable and support sustained human and robotic exploration of Mars and more distant destinations. The first robotic mission will be no later than 2008.

1.1 By 2008, conduct the first robotic lunar testbed mission.

6SSE1 Complete Lunar Reconnaissance Orbiter (LRO) Preliminary Design Review (PDR).

2. Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration.

2.1 Characterize the present climate of Mars and determine how it has evolved over time.

6SSE15 Successfully demonstrate progress in characterizing the present climate of Mars and determining how it has evolved over time. Progress toward achieving outcomes will be validated by external expert review.

2.2 Understand the history and behavior of water and other volatiles on Mars.

6SSE16 Successfully demonstrate progress in understanding the history and behavior of water and other volatiles on Mars. Progress toward achieving outcomes will be validated by external expert review.

2.3 Understand the chemistry, mineralogy, and chronology of Martian materials.

6SSE17 Successfully demonstrate progress in understanding the chemistry, mineralogy, and chronology of Martian materials. Progress toward achieving outcomes will be validated by external expert review.

6SSE23 Complete successful Martian orbit insertion for Mars Reconnaissance Orbiter (MRO).

2.4 Determine the characteristics and dynamics of the interior of Mars.

6SSE18 Successfully demonstrate progress in determining the characteristics and dynamics of the interior of Mars. Progress toward achieving outcomes will be validated by external expert review.

2.5 Understand the character and extent of prebiotic chemistry on Mars.

6SSE19 Successfully demonstrate progress in understanding the character and extent of prebiotic chemistry on Mars. Progress toward achieving outcomes will be validated by external expert review.

6SSE24 Complete 2009 Mars Telecommunications Orbiter (MTO) Preliminary Design Review (PDR).

2.6 Search for chemical and biological signatures of past and present life on Mars.

6SSE20 Successfully demonstrate progress in searching for chemical and biological signatures of past and present life on Mars. Progress toward achieving outcomes will be validated by external expert review.

6SSE25 Complete Mars Science Laboratory Preliminary Design Review (PDR).

2.7 Identify and understand the hazards that the Martian environment will present to human explorers.

6SSE21 Successfully demonstrate progress in identifying and understanding the hazards that the Martian environment will present to human explorers. Progress toward achieving outcomes will be validated by external expert review.

2.8 Inventory and characterize Martian resources of potential benefit to human exploration of Mars.

6SSE22 Successfully demonstrate progress in inventorying and characterizing Martian resources of potential benefit to human exploration on Mars. Progress toward achieving outcomes will be validated by external expert review.

3. Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore Jupiter's moons, asteroids and other bodies to search for evidence of life, to understand the history of the solar system, and to search for resources.

3.1 Understand the initial stages of planet and satellite formation.

6SSE7 Successfully demonstrate progress in understanding the initial stages of planet and satellite formation. Progress toward achieving outcomes will be validated by external expert review.

6SSE26 Successfully return Stardust science samples to Earth.

3.2 Understand the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact.

6SSE8 Successfully demonstrate progress in understanding the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact. Progress toward achieving outcomes will be validated by external expert review.

3.3 Understand why the terrestrial planets are so different from one another.

6SSE9 Successfully demonstrate progress in understanding why the terrestrial planets are so different from one another. Progress toward achieving outcomes will be validated by external expert review.

6SSE27 Successfully launch Dawn spacecraft.

6SSE28 Successfully complete MESSENGER flyby of Venus.

3.4 Learn what our solar system can tell us about extra-solar planetary systems.

6SSE10 Successfully demonstrate progress in learning what our solar system can tell us about extra-solar planetary systems. Progress toward achieving outcomes will be validated by external expert review.

3.5 Determine the nature, history, and distribution of volatile and organic compounds in the solar system.

6SSE11 Successfully demonstrate progress in determining the nature, history, and distribution of volatile and organic compounds in the solar system. Progress toward achieving outcomes will be validated by external expert review.

3.6 Identify the habitable zones in the solar system.

6SSE12 Successfully demonstrate progress in identifying the habitable zones in the solar system. Progress toward achieving outcomes will be validated by external expert review.

3.7 Identify the sources of simple chemicals that contribute to pre-biotic evolution and the emergence of life.

6SSE13 Successfully demonstrate progress in identifying the sources of simple chemicals that contribute to pre-biotic evolution and the emergence of life. Progress toward achieving outcomes will be validated by external expert review.

3.8 Study Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere.

6SSE14 Successfully demonstrate progress in studying Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere. Progress toward achieving outcomes will be validated by external expert review.

3.9 By 2008, inventory at least 90 percent of asteroids and comets larger than one kilometer in diameter that could come near Earth.

6SSE5 Successfully demonstrate progress in determining the inventory and dynamics of bodies that may pose an impact hazard to Earth. Progress toward achieving outcomes will be validated by external expert review.

3.10 Determine the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth.

6SSE6 Successfully demonstrate progress in determining the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth. Progress toward achieving outcomes will be validated by external expert review.

Efficiency Measures

6SSE29 Complete all development projects within 110% of the cost and schedule baseline.

6SSE30 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6SSE31 Peer review and competitively award at least 80%, by budget, of research projects.

6SSE32 Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days.

Program Management

Solar System Exploration (SSE) Theme Director is Mr. Andrew A Dantzler, Acting Director of the Solar System Exploration Division.

Quality

Independent Reviews:

- NASA Advisory Council (NAC) - Review science strategy, program implementation strategy
- National Research Council - Advises on long-term scientific strategies
- National Research Council (Space Studies Board) - Review effectiveness and quality of the programs
- Space Science Advisory Council (SScAC) - Review science strategy and program implementation strategy
- Solar System Exploration Sub-Committee - Review science strategy and program implementation strategy
- Mars Program Independent Assessment Team (MPIAT) - Analyze success and failures of recent Mars and Deep Space missions
- Mars Exploration Program Advisory Group (MEPAG, Peer Review) - Refine and evaluate the scientific objectives and research focus areas

Program Assessment Rating Tool (PART):

Mars and Solar System Exploration were two separate themes prior to the FY 2006 budget and received "Effective" ratings in their previous PART assessments. Each received an overall score of 87%.

Additionally, the assessment concluded that SSE is a "well defined, well managed program with clear purpose and direct ties to NASA's mission." The Theme was also praised for taking seriously the research priorities of the planetary science community, having a diverse mission portfolio, and learning from mission failures.

Theme: Solar System Exploration

Budget Detail (Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Solar System Exploration	**1,909.5**	**1,858.1**	**42.4**	**1,900.5**	
Discovery	272.4	180.6	-12.0	168.7	
New Frontiers	147.5	210.8	-52.2	158.6	
Technology	193.4	130.7	-35.1	95.7	
Deep Space Mission Systems	265.3	257.7	-0.2	257.4	
Solar System Research	417.5	345.2	17.3	362.5	
Mars Exploration	596.3	681.1	42.0	723.1	
Robotic Lunar Exploration	17.0	52.0	82.6	134.6	

- Discovery Program: Transferred to Kepler mission, a Discovery project, to the Universe Theme.
- Mars Program - Supports the ramp up for the 2009 Mars Telesat (MTO), Optical, and 2009 Mars Science Lab (MSL).
- New Frontiers Program - Delayed initiation for the development of New Frontiers 2 mission by about four months.
- Initiate Lunar Robotic program, and supports the ramp up for the 2008 Lunar Robotic Orbiter (LRO) mission.
- Technology - Eliminated In-Space Propulsion (ISP) MXER and Hall technologies, and a one year delay of aerocapture, Solar Sails and Next Generation Electric Propulsion (NEXT) form achieving TRL 6.
- Provides for Directorate program reserve and institutional cost adjustments.

Theme: Solar System Exploration
Program: Discovery

President's FY 2006 Budget Request

(Dollars in Millions)

Discovery	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	272.4	180.6	168.7	219.2	301.5	319.7	334.3

Overview

Robotic space exploration holds tremendous possibilities for exploration and discovery. Even with the vast amount of knowledge gained since exploration of the solar system began, there are still many more questions than answers. NASA's Discovery program gives scientists the opportunity to dig deep into their imaginations and find innovative ways to unlock the mysteries of the solar system. It represents a breakthrough in the way NASA explores space, with lower-cost, highly focused planetary science investigations designed to enhance our understanding of the solar system. All completed Discovery missions (NEAR, Mars Pathfinder, and Lunar Prospector) have achieved ground-breaking science, with each taking a unique approach to space exploration. Discovery is an ongoing program that offers the scientific community the opportunity to assemble a team and design exciting, focused science investigations that complement NASA's larger planetary science explorations.

Artist's conception of a Discovery program mission.

Current Discovery operating projects include Stardust, Aspera-3, MESSENGER, and Deep Impact. Stardust, launched in February 1999, rendezvoused with Wild 2 comet in January 2004, and will bring samples of interstellar dust back to Earth. Genesis, a solar wind particle sample return mission, launched in July 2001, landed unsuccessfully but it was able to recover samples. MESSENGER, a mission to Mercury, will orbit Earth for a gravity assist, fly past Venus twice, and use Venus's gravity to rotate its trajectory closer to Mercury's orbit.

http://discovery.nasa.gov/missions

Plans For FY 2006

Stardust - Successfully return Stardust Science samples to Earth in January 2006
MESSENGER - Successfully complete preparations for first flyby of Venus
Dawn - Successfully launch by July 2006
Future Missions - Select Discovery 11 concept study

Changes From FY 2005

- A one year delay in the selection of Discovery 11 concept study
- Dawn Project - Deleted 2 instruments (laser altimeter and magnetometer), a one month launch delay (from May 2006 to June 2006), and reduced encounter with Vesta (from 11 to 7) and Ceres (from 11 to 5)
- Kepler - launch date moved from 10/07 to TBD

Theme: Solar System Exploration
Program: Discovery

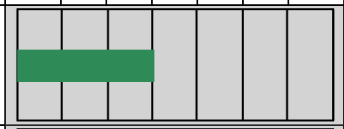
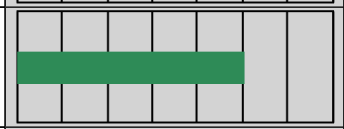
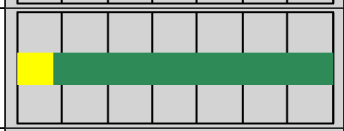
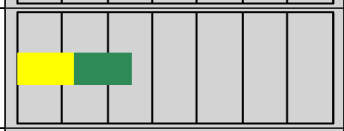
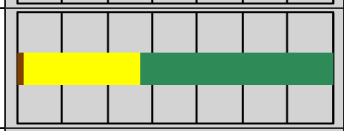
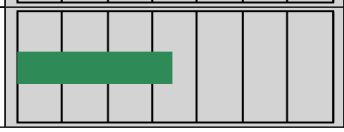
Program Management

Discovery program management is delegated to Marshall Space Flight Center. Scientific mission priorities and assignment responsibilities reside HQ.

Technical Description

Since the inception of the Discovery program, ten missions (NEAR, Mars Pathfinder, Lunar Prospector, Stardust, CONTOUR, Genesis, MESSENGER, Deep Impact, Dawn and Kepler) and a Mission of Opportunity (Aspera-3) were selected. NEAR, Mars Pathfinder and Lunar Prospector were extremely successfully and over achieved their science goals. CONTOUR, launched in July 2002 and the only Discovery failed mission, was lost mainly due mostly to plume heating during the embedded solid-rocket motor burn. Genesis landed unsuccessfully, but was able to return science samples of the solar wind particles back to Earth. Stardust, MESSENGER, Aspera-3, and Deep Impact all launched successfully, and are currently in the operation and data analysis phase. Dawn and Kepler are in the development phase.

Implementation Schedule:

Project	Schedule by Fiscal Year	Purpose	Phase Dates		
	04 05 06 07 08 09 10			Beg	End
Stardust		A mission to bring samples of interstellar dust back to Earth.	Tech Form Dev Ops Res	 Feb-99 Feb-99	 Feb-99 Sep-06 Sep-06
Genesis		A mission to bring samples of solar wind particles back to Earth.	Tech Form Dev Ops Res	 Aug-01 Aug-01	 Aug-01 Sep-08 Sep-08
MESSENGER		A mission to Mercury to conduct an in-depth study of the Sun's closest neighbor.	Tech Form Dev Ops Res	 Sep-00 Jun-01 Aug-04 Aug-04	 Jun-01 Aug-04 Mar-12 Mar-12
Deep Impact		A mission to study the composition of the interior of a comet.	Tech Form Dev Ops Res	 May-00 Mar-01 Jan-05 Jan-05	 Mar-01 Jan-05 Mar-06 Mar-06
Dawn		To significantly increase our understanding of the solar system's earliest history by examining the geophysical and geochemical properties of the main belt asteroid 1 Ceres and 4 Vesta.	Tech Form Dev Ops Res	 Sep-02 Dec-03 Jun-06 Jun-06	 Dec-03 Jun-06 Jul-14 Jul-14
ASPERA-3		ASPERA-3 is one of seven scientific instruments aboard the Mars Express spacecraft, with an objective to search for sub-surface water from orbit and drop a lander on the Martian surface.	Tech Form Dev Ops Res	 Sep-02 Jun-03 Jun-03	 Jun-03 Mar-07 Mar-07

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

Strategy For Major Planned Acquisitions

- The Discovery program will solicit proposals for an entire mission, put together by a team comprised of people from industry, small businesses, government and universities, led by a PI.
- With the exception of future NASA Announcement of Opportunities, all major acquisitions are in place.

Key Participants

- Stardust - Principal Investigator and Lead Scientist, University of Washington
- MESSENGER - Principal Investigator and Lead Scientist, Department of Terrestrial Magnetism at the Carnegie Institution of Washington
- Genesis - Principal Investigator and Lead Scientist, California Institute of Technology

  Deep Impact - Principal Investigator and Lead Scientist, University of Maryland
- Dawn - Principal Investigator and Lead Scientist, University of California at Los Angeles

  ASPERA-3 - Principal Investigator and Lead Scientist, Southwest Research Institute

Theme: Solar System Exploration
Program: New Frontiers

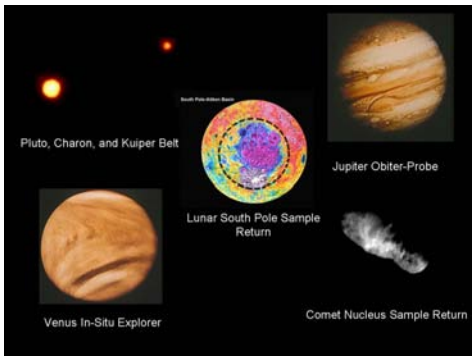
President's FY 2006 Budget Request

(Dollars in Millions)

New Frontiers	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	147.5	210.8	158.6	157.7	162.6	259.4	259.0

Overview

The New Frontiers program, a class of competed medium-sized missions, represents a critical step in the advancement of the solar system exploration. Proposed science targets for the New Frontiers program include Pluto and the Kuiper Belt, Jupiter, Venus, and sample returns from Earth's Moon and a comet nucleus. The flight rate is expected to be about one mission every three years.



Science targets for New Frontiers Program

New Horizons is the first of the New Frontiers missions. New Horizons will conduct a reconnaissance of the Pluto-Charon system and the Kuiper Belt. This mission is scheduled to launch aboard an Atlas V launch vehicle in January 2006.

Two candidate concepts have been selected for New Frontiers 2 for concept studies in July 2005, a Step-2 selection (downselect to just one mission) is targeted in July 2005. However, funding limitations may force the initiation of the downselect development work into FY 2006.

http://centauri.larc.nasa.gov/newfrontiers/

Plans For FY 2006

New Horizons:
- Flight Readiness Review - 12/05
- Successfully launch - 1/06

New Frontiers 2:
- Step 2 or downselect - 7/05, funding limitations may force the initiation of the downselected development work into FY 2006

Changes From FY 2005

- 2 month delay (from 5/05 to 7/05) in Step 2 or downselect of the New Frontiers 2 mission. However, funding limitations may force the initiation of the downselected development work into FY 2006.

Program Management

New Frontiers program management is delegated to MSFC. Scientific mission priorities and assignment responsibilities reside at NASA Headquarters, SMD.

Theme: Solar System Exploration
Program: New Frontiers

Technical Description

New Horizons is scheduled to launch aboard an Atlas V launch vehicle in January 2006, swing past Jupiter for a gravity boost and scientific studies in February 2007, and reach Pluto and its moon, Charon, in July 2015. Then the spacecraft may head deeper into the Kuiper Belt to study one or more of the icy mini-worlds in that vast region, at least a billion miles beyond Neptune's orbit.

Technical description for future New Frontiers missions to be defined upon mission(s) selection.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
New Horizons								Will conduct reconnaissance of Pluto and its moon Charon.	Tech	Sep-01	Oct-01
									Form	Oct-01	Mar-03
									Dev	Mar-03	Jan-06
									Ops	Jan-06	Dec-20
									Res	Jan-13	Dec-20

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

Strategy For Major Planned Acquisitions

- The New Frontiers program will solicit proposals for an entire mission, put together by a team comprised of people from industry, small businesses, government and universities, led by a PI.
- Major acquisitions for the New Horizons project are in place. Acquisitions for mission(s) beyond New Horizon are to be defined upon mission(s) selection.

Key Participants

- New Horizons: Johns Hopkins University/Applied Physics Laboratory has project management responsibility
- New Horizons: Principal Investigator - Southwest Research Institute

Risk Management

- RISK: New Horizons: Nuclear launch approval process and schedule, launch vehicle certification schedule, Observatory delivery schedule, and overall project cost. MITIGATION: NASA Headquarters has chartered the Discovery and New Frontiers program office at MSFC to perform an Independent Assessment of the New Horizon mission with respect to the following: #1)assess the mission's readiness to support a January 2006 launch date and #2)assess the project's ability to deliver the spacecraft and instruments that meet the AO-based contractual requirements.

Theme: Solar System Exploration
Program: Technology

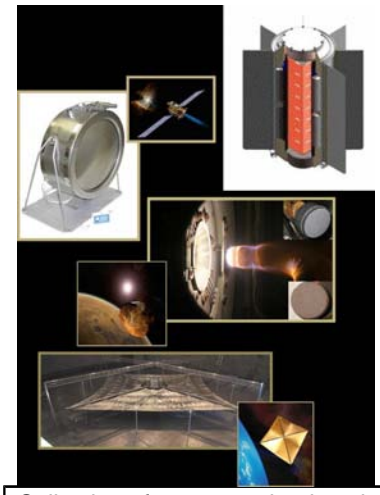
President's FY 2006 Budget Request

(Dollars in Millions)

Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	193.4	130.7	95.7	129.3	128.0	129.1	130.4

Overview

Solar system exploration is a challenging endeavor. Robotic spacecraft use electrical power for propulsion, data acquisition, and communication to accurately place themselves in orbit around and onto the surfaces of bodies about which we may know relatively little. These systems ensure that they survive and function in hostile and unknown environments, acquire and transmit data throughout their lifetimes, and sometimes transport samples back to Earth. Since successful completion of these missions is so dependent on power, the future SSE portfolio of missions will demand advances in power and propulsion systems.



Collection of current technology investment

Radioisotope Power Systems (RPS) continue to provide a substantial increasing power for the spacecraft on missions to the outer planets, and have revolutionized NASA's capability to explore the solar system. Increased power for spacecraft means not only traveling farther or faster, but also exploring more efficiently with greater scientific return. The In-Space Propulsion Program (ISPP) develops non-nuclear technologies that can enable or benefit NASA robotic missions (including Discovery, New Frontiers, Mars, and may include Living with a Star missions) by significantly reducing cost, mass, and/or travel times. ISPP supports the Vision for Exploration by providing new transportation capabilities for robotic science and exploration. The fundamental benefit of ISPP results in an increase in the return of scientific data and a shorter cycle of space science experimentation.

Plans For FY 2006

In-Space Power Program (ISPP): Validate by test a Next Generation Xenon Thruster in an integrated system, including power processor and propellant management system (first generation product delivery) with a goal of testing a multi-thruster configuration. Additional investments are being made with the goal of achieving TRL 6 in FY 2007, first generation product delivery. Demonstrate the rigid aeroshell concept on the ground via mechanical and thermal tests of two different integrated aeroshell systems, incorporating thermal protection and sensor systems.

Radioisotope Power System (RPS): Assuming that NEPA compliance assessments support proceeding with flight system development, final design, fabrication and testing of the Qualification Units for both Multi Mission Radioisotope Thermoelectric Generator (MMRTG) and Sterling Radioisotope Generator (SRG) would take place in 2006.

Theme: Solar System Exploration
Program: Technology

Changes From FY 2005

- In-Space Propulsion: One year delay of aerocapture, Solar Sails and Next Generation Electric Propulsion (NEXT 9kw engine) from achieving TRL-6 by FY 2006. Eliminated MXER and HALL technology tasks.
- Radioisopte Power System (RPS): Deleted Small RPS or second generation Sterling (SRG), and RPS Power Conversion Technology (RPCT).

Program Management

MSFC is responsible for ISPP, while Headquarters is responsible for managing the RPS program. Both technology programs reside in SMD, SSE Theme.

Technical Description

The ISPP portfolio has enabling or beneficial application to missions on approved agency roadmaps. The high priority technology areas are Solar Electric Propulsion (Next Generation Electric Propulsion), Solar Sail Propulsion and Aerocapture Technology; additional investments are being made in the areas of Advanced Chemical and Tether Propulsion. Other technology areas will be established as required to meet NASA priorities. RPS program objectives are 1) develop new radioisotope power sources for missions that would launch by the end of the decade; 2) advance promising power conversion technologies to increase the specific power and performance of future RPS units; and 3) assess and facilitate the use of advanced RPS technologies for new mission application.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
In-Space Propulsion Program (ISPP)								On-going and continuous research and develop non-nuclear in-space propulsion technologies for near, mid, and long-term NASA robotic missions.	Tech Form Dev Ops Res	Oct-03	Sep-50
Radioisotope Power Systems (RPS)								On-going and continuous to research and develop power system technologies that can enable or benefit near- and mid-term NASA robotic exploration missions.	Tech Form Dev Ops Res	Oct-02	Sep-50

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

Strategy For Major Planned Acquisitions

- With the exception of selections to be made via the ROSES NRAs, which are competitive and peer reviewed, all major acquisitions are in place for both the ISP and RPS technology programs.

Key Participants

- The U.S. Department of Energy (DOE) supports NASA by leading development and delivery of the MMRTG and SRG. DOE is also responsible for the purchase of Plutonium-238 (Pu-238) fuel from Russia, and processing, fabrication and integration of Pu-238 heat sources.

Theme: Solar System Exploration
Program: Deep Space Mission Systems (DSMS)

President's FY 2006 Budget Request

(Dollars in Millions)

Deep Space Mission Systems (DSMS)	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	265.3	257.7	257.4	251.6	260.6	267.7	273.4

Overview

Deep Space Mission System (DSMS) Program seeks to enable NASA exploration, both human and robotic, of the solar system and beyond by providing reliable, high performance, and cost effective telecommunications and navigation services to its lunar and deep space missions.

The Goldstone Deep Space Communications Complex, located in the Mojave Desert in California, is one of three complexes which comprise NASA's Deep Space Network (DSN).

DSMS objectives include: 1)Develop and evolve an operations concept and architecture for lunar and deep space communications, navigation, and information systems that enable NASA exploration throughout the 21st century; 2)Improve communications between Earth and deep space to enable new classes of future NASA missions provide a minimum of 1,000 fold and up to a 1,000,000 fold increase in end-to-end mission information return capability by 2030; 3)Improve tracking and navigation services to enhance current capabilities as well as enable new classes of future NASA missions; 4)Improve the operability of DSMS from the mission perspective. In particular, provide a user interface that is responsive, easy to understand, easy to use, and provides the user insight into the quality of provided services; 5)Leverage NASA's deep space communications and navigation capabilities to provide support to specific classes of near-Earth missions where technically and economically appropriate; 6)inspire and mentor the next generation of engineers and scientists, and engage the public at large; and 7)Pioneer deep space communication and navigation techniques, technologies, and supporting information systems.

Project elements within DSMS include the Deep Space Network (DSN, both optical and radio) and the Advanced Multi-Mission Operations Support (AMMOS).

http://deepspace.jpl.nasa.gov/dsn/

Plans For FY 2006

DSN will not only continue to support current missions, but will also plan for and make technology investments to support the Vision for Exploration. It is anticipated that Deep Space Network (DSN) will return a 1000-1,000,000-fold increase in data than is now possible at a much lower cost than today's DSN.

DSN will continue to acquire telemetry data from spacecraft, and transmit commands to spacecraft, track spacecraft position and velocity in support of about 35 missions in FY06 Dawn, Image,TOMS-EP, Deep Impact, Ulysses, GOES-13 (for NOAA), Mars Science Laboratory, Genesis, RadarSat (Canadian mission), Spirit and Opportunity the 2003 Mars Exploration Rovers, Voyagers 1 and 2, ISTP (Cluster, Geotail, Polar, Wind), Cassini, SOHO, ACE, Mars Express, Integral (ESA mission), Muses-C (Japanese), Mars Global Surveyor, Chandra, SELENE (Japanese), MESSENGER, MAP, Stardust, 2001 Mars Odyssey, Rosetta, MRO, Spitzer, GSSR, Space Geodesy, and Lunar-A (Japanese).

AMMOS will continue to provide navigation and design tools and provide training to flight missions, perform resource allocations, and undertake technology investments for improved communications and navigation technologies.

Optical will continue to provide technical guidance and development of components for future deep space optical communications.

The program will actively develop standards that reduce the cost of developing and operating newer missions and enable a seamless connectivity and interoperability across the solar system mission assets and thereby reduce risk and increase the probability of mission success.

Changes From FY 2005

- There are no changes.

Program Management

JPL is responsible for Deep Space Mission System (DSMS) program management and oversight.

Technical Description

DSN is a global network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe, as well as selected Earth-orbiting missions. The DSN consists of three deep-space communications facilities placed at longitudes approximately 120 degrees apart around the world: Goldstone, California, Madrid, Spain, and Canberra, Australia. AMMOS is a set of tools and services that are an integral part of NASA deep space missions, providing standard mission environments to reduce the total cost of NASA missions. Optical provides technical guidance and development of components for future deep space optical communications, including develop roadmap for long-term architecture and technology requirements.

Theme: Solar System Exploration
Program: Deep Space Mission Systems (DSMS)

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Advanced Multi-mission Operation System								Provide navigation and design tools to improve communications and navigation technologies.	Tech Form Dev Ops Res	Oct-03	Sep-10
Deep Space Network								Acquire telemetry data from sapcecraft and transmit commands to spacecraft.	Tech Form Dev Ops Res	Oct-03	Sep-10
Optical Long-term Tech								Provide technical guidance and development of components for future deep space optical communications.	Tech Form Dev Ops Res	Oct-03	Sep-10

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

Key Participants

- Spain and Australia - tracking stations near Madrid and near Canberra.
- France, Germany, Italy, Japan, and the United Kingdom - data transfer protocol standards working group
- DOD - Laser Communication, member in the Deep Space Network Executive Management Board
- Russia - member of tracking interoperability working group of which NASA is a part

Risk Management

- RISK: Fragile infrastructure due to aging and risk of breakage. MITIGATION: Studies, prioritization of work, implementation. In the first half of FY05: 1) -Requirements reviews in 8 areas that cover all of DSMS activities to determine precisely what work needs to be done; 2) -Engaging an outside engineering firm to provide in-depth analysis of Goldstone facilities upgrade requirements; 3) -Single points of failure analysis throughout the DSN.

Theme: Solar System Exploration
Program: Solar System Research

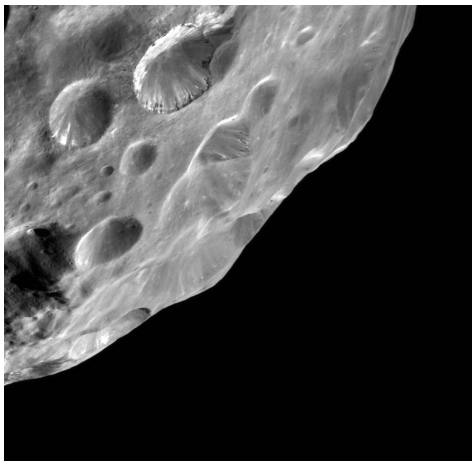
President's FY 2006 Budget Request

(Dollars in Millions)

Solar System Research	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	417.5	345.2	362.5	370.2	374.3	374.8	381.8

Overview

The Solar System Exploration (SSE) Research Program develops the theoretical tools and laboratory data needed to analyze flight data, makes possible new and better instruments to fly on future missions, and analyzes the data returned so that SSE can answer specific questions posed and fit this new knowledge into the overall picture of the solar system. This program represents an essential complement to flight missions, providing the scientific research and theoretical foundation that allows the nation to fully utilize the unique data sets returned from the solar system.



Cassini image of 6-Phoebe

The SSE Research Program element includes Research and Analysis (R&A); the operations and analysis of data for Cassini, Rosetta, and Hayabusa (Muses-C) missions; and the science data tools and archives needed to perform and catalog the research.

The scope of R&A programs is wide because they must provide the new theories and instrumentation that enable the next generation of flight missions. The alignment of research program with SSE strategic goals is maintained by 1) ensuring the NASA Research Announcements soliciting R&A proposals contain explicit instructions that proposals must identify, and 2) addressing one or more elements of the Science Mission Directorate and NASA's Exploration Vision.

Cassini-Huygens is an international collaboration mission to Saturn and is the first to explore the Saturn system of rings and moons. Rosetta, an ESA/NASA comet rendezvous mission launched in March 2004, and Hayabusa (Muses-C-), a joint Japanese/NASA mission to asteroid 4660 Nereus and return a sample, are also included in the Research Program.

Plans For FY 2006

- Continue with the operations and data analysis of the Cassini, Rosetta, and Hayabusa (Muses-C) missions.
- Continue planetary science data archiving and releasing of this data to the science community in a timely manner.
- Release Research Announcements soliciting R&A proposals and make selections.

Changes From FY 2005

- There are no changes.

Theme: Solar System Exploration
Program: Solar System Research

Program Management

NASA Headquarters is responsible for R&A program management; Jet Propulsion Lab (JPL) has responsibility for Cassini, Rosetta, and Hayabusa (Muses-C).

Technical Description

Research and Analysis (R&A) provides the foundation for the formulation of new scientific questions and strategies. It supports research tasks such as astrobiology and cosmochemistry, the origins and evolution of planetary systems, the atmospheres, geology, and chemistry of the solar system's planets (other than Earth). Additionally, it provides for instruments and measurement concepts, and supports the initial definition and development of instruments for future Discovery, New Frontiers, or Mars missions. Cassini (a mission to Saturn that will help us better understand Saturn, its famous rings, its magnetosphere, and Titan), Rosettta (ESA Comet rendezvous mission), and Hayabusa/Muses-C (JAXA asteroid sample return mission) are included within the Research Program.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Cassini								A mission to Saturn and it's major moon (Titan).	Tech		
									Form		
									Dev	Oct-89	Oct-97
									Ops	Oct-97	Jul-08
									Res	Dec-00	Jul-08
Rosetta								An ESA mission to 46 P/Wirtanen Comet.	Tech		
									Form		
									Dev	Jun-97	Mar-04
									Ops	Mar-04	Sep-16
									Res	Mar-04	Sep-16
Hayabusa (Muses-C)								JAXA asteroid sample return mission with US science participation.	Tech		
									Form		
									Dev	Feb-98	Jul-02
									Ops	Jul-02	Aug-07
									Res	Jul-02	Sep-09

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

Strategy For Major Planned Acquisitions

- The FY2006 budget will fund competitively selected activities from the ROSES-05 (Research Opportunities in Space and Earth Science)Omnibus NRA.

Key Participants

- Cassini - The Huygens probe was built by the European Space Agency
- Cassini - The Italian Space Agency provided Cassini's high-gain communication antenna
- Rosetta - The European Space Agency (ESA) built the spacecraft, provided the launch vehicle, and operates the spacecraft
- Hayabus (Muses-C) - Japan Aerospace Exploration Agency (JAXA) responsibilities include the spacecraft, launch vehicle, and operations

Theme: Solar System Exploration
Program: Mars Exploration

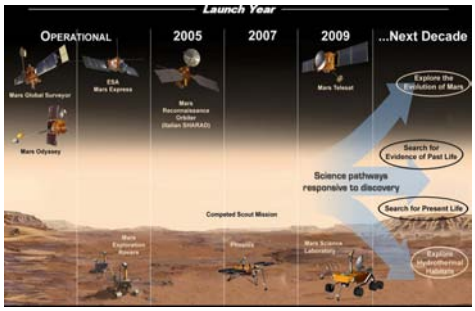
President's FY 2006 Budget Request

(Dollars in Millions)

Mars Exploration	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	596.3	681.1	723.1	943.5	1,233.4	1,232.0	1,260.2

Overview

Mars has captured the imagination of generations, from the discovery of "canals" in the 19th century to H.G. Wells' War of the Worlds. Additionally, Mars is the most Earth-like planet in our solar system, with land mass approximately equivalent to the Earth's landmass and what appear to be familiar features such as riverbeds, past river deltas, and volcanoes. Not only is Mars common in our folklore and imagination, but it also holds valuable scientific clues to the development of the solar system, planets, and maybe life itself. The Mars Exploration Program has been developed to conduct a rigorous, incremental, discovery-driven exploration of Mars to determine the planet's physical, dynamic, and geological characteristics, investigate the Martian climate in the context of understanding habitability, and investigate whether Mars ever had the potential to develop and harbor any kind of life. Discoveries from recent missions such as Mars Odyssey and the Mars Exploration Rovers (Spirit and Opportunity) have provided convincing evidence of significant amounts of liquid water on Mars in the past. This evidence supports the program's goals, mission sequences, and overall approach to searching for past or present life on Mars through following a key ingredient of life as we know it - water.



Mars Exploration 10 year program.

The MEP Homepage can be accessed at:
http://marsprogram.jpl.nasa.gov/overview/

Plans For FY 2006

- 2005 Mars Reconnaissance Orbiter (MRO) starts Mars orbit insertion and begins science investigations.
- 2007 Phoenix (Mars Scout), enters assembly, integration, and test phase.
- 2009 Mars Telecommunications Orbiter (MTO) starts Preliminary Design Review (PDR), and Optical Communication Payload starts Critical Design Review (CDR).
- 2009 Mars Science Laboratory (MSL) starts Preliminary Design Review (PDR).
- Mars Scouts number 2 release Announcement of Opportunity (AO).

Changes From FY 2005

- There are no changes.

Program Management

JPL has program responsibility; Theme responsibility resides at NASA HQ/SMD.

Theme: Solar System Exploration
Program: Mars Exploration

Technical Description

The MEP is composed of a number of synergistic elements that achieve the programmatic and scientific goals of the program. The technology program supports future missions through competitive selection of base, focused, and instrument-specific development. Science research is fostered through competitive selections for scientific research, and missions are developed through largely competitive (and limited non-competative) processes, including core MEP missions and community-driven competitive Scout missions. MEP is currently operating Global Surveyor, Odyssey, and the Mars Exploration Rovers at Mars, conducting ground-breaking science and providing orbit communications relay for the rovers. Missions in development include MRO(8/2005), Phoenix(2007), MSL(2009) and MTO/MLCD(2009).

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Mars Global Surveyor (MGS)								To study the entire Martian surface, atmosphere, and interior, and has returned more data about the red planet than all other Mars missions combined.	Tech		
									Form		
									Dev		Nov-96
									Ops	Nov-96	Sep-06
									Res	Sep-97	Sep-06
Odyssey								To study the geology, geophysics and climate of Mars.	Tech		
									Form		
									Dev		Apr-01
									Ops	Apr-01	Mar-07
									Res	Oct-01	Sep-07
MER (Spirit & Opportunity)								To search for evidence of liquid water that may have been present in the planet's past	Tech		
									Form	May-00	Jul-00
									Dev	Jul-00	Jul-03
									Ops	Jul-03	Mar-05
									Res	Jan-04	Sep-05
Mars Reconnaissance Orbiter (MRO)								Take close-up pictures of the martian surface, analyze minerals, look for subsurface water, trace how much dust and water are distributed in the atmosphere, and monitor daily global weather.	Tech		
									Form	Jan-01	Jul-02
									Dev	Jul-02	Aug-05
									Ops	Aug-05	Dec-10
									Res	Mar-06	Dec-10
Mars Express								The ESA and the ISA Mars mission, with a US participation, launched in June 2, 2003, to explore the atmosphere and surface of Mars from polar orbit.	Tech		
									Form	Jan-00	Sep-00
									Dev	Sep-00	Jun-03
									Ops	Jun-03	Dec-05
									Res	Dec-03	Sep-06
Mars Science Laboratory (MSL)								To collect martian soil samples and rock cores and analyze them for organic compounds and environmental conditions that could have supported microbial life now or in the past.	Tech		
									Form	Nov-03	Aug-05
									Dev	Aug-05	Nov-09
									Ops	Nov-09	Oct-12
									Res	Nov-10	Sep-13
Phoenix								The first in a new line of smaller competed "Scout" missions in the agency's Mars Exploration Program to detect life by looking for complex organic molecules.	Tech		
									Form	Aug-03	Mar-05
									Dev	Mar-05	Aug-07
									Ops	Aug-07	Oct-08
									Res	May-08	Oct-09

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

Strategy For Major Planned Acquisitions

- NASA has set a goal of open competition for all missions. All major acquisitions for MRO, Phoenix, and MSL are in place; major acquisitions for MTO are in the selection process.

Key Participants

- MRO - Lockheed Martin is the Spacecraft Design/Systems Integrator

  MRO - Ball Aerospace for the primary optical instrument
- Phoenix - Principle Investigator and Lead Scientist, Arizona State
- MTO/MLCD - Goddard Space Flight Center for the Laser Communications Demonstration (MLCD), and MTO's system integrator selection process is currently underway.
- MSL - Department of Energy for Multi Mission Radioisotope Termoelectric Generators

Risk Management

- RISK: MEP manages program risk through project-specific implementation. Since the majority of MEP risk is encountered during flight mission development, and each project is unique in it's technical and financial challenges, risk must also be managed according to each project's specific needs. MEP, JPL, and NASA HQ require rigorous risk management to be employed on each project. MITIGATION: Project risks are reviewed and discussed, and mitigation approaches and progress are evaluated by the JPL program office and NASA program director on a monthly basis. Risks are ranked in the NASA 5X5 matrix and risks that are deemed to be problems are elevated and managed accordingly to closure.

Theme: Solar System Exploration
Program: Robotic Lunar Exploration

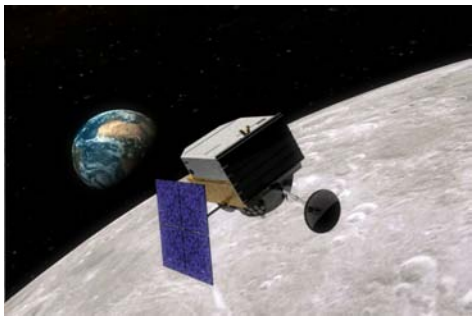
President's FY 2006 Budget Request

(Dollars in Millions)

Robotic Lunar Exploration	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	17.0	52.0	134.6	276.1	371.4	416.2	427.0

Overview

Robotic Lunar Exploration (RLE) Program will undertake lunar exploration activities that enable sustained human and robotic exploration of the Moon. These activities will further science, and develop and test new approaches, technologies, and systems, including use of lunar and other space resources, to support sustained human space exploration.



LRO spacecraft and payload - artist's Conception

RLE will develop precursor lunar missions in response to mission and technology requirements defined by the Exploration Systems Directorate. RLE missions will infuse the technologies and test the operations modes that NASA will employ in human and robotic solar system exploration. Launch of LRO in 2008 is necessary to meet the President's mandate to land humans on the moon between 2015 and 2020.

The specific number, frequency, duration, sizes and types of lunar missions and systems NASA ultimately deploys will be determined based on: the capabilities requiring demonstration on or near the Moon; the operational concepts being considered for future human and robotic exploration of Mars and other solar system destinations; and the research results from ongoing robotic missions to Mars and other solar system destinations. Robotic Lunar Exploration will develop and conduct a robotic lunar orbital mission, launching by 2008, and a robotic lunar surface mission, launching by 2009, to test system capabilities, and gather engineering data for future development.

RLE Homepage can be accessed at:
http://lunar.gsfc.nasa.go

Plans For FY 2006

The Lunar Reconnaissance Orbiter (LRO) is the only Robotic Lunar Exploration program project in formulation. Other missions for the Robotic Lunar exploration program are in pre-formulation.

Changes From FY 2005

- LRO entered the formulation.

Program Management

The Robotic Lunar Exploration program is delegated to the Goddard Space Flight Center. Theme responsibility resides at SMD/ NASA Headquarters.

Theme: Solar System Exploration
Program: Robotic Lunar Exploration

Technical Description

The Robotic Lunar Exploration (RLE) program is responsible for undertaking lunar exploration activities to advance lunar science and to enable sustained human and robotic exploration of Mars and more distant destinations in the solar system and initiating a series of robotic missions to the moon to prepare for and support future human exploration activities. In addition the RLE Program will use lunar exploration activities to develop and test new approaches, technologies, and systems, to support sustained human space exploration to Mars and other destinations.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
LRO									Tech		
									Form	Jan-05	May-05
									Dev	May-05	Oct-08
									Ops	Oct-08	Dec-09
									Res	Nov-09	Dec-09

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

Strategy For Major Planned Acquisitions

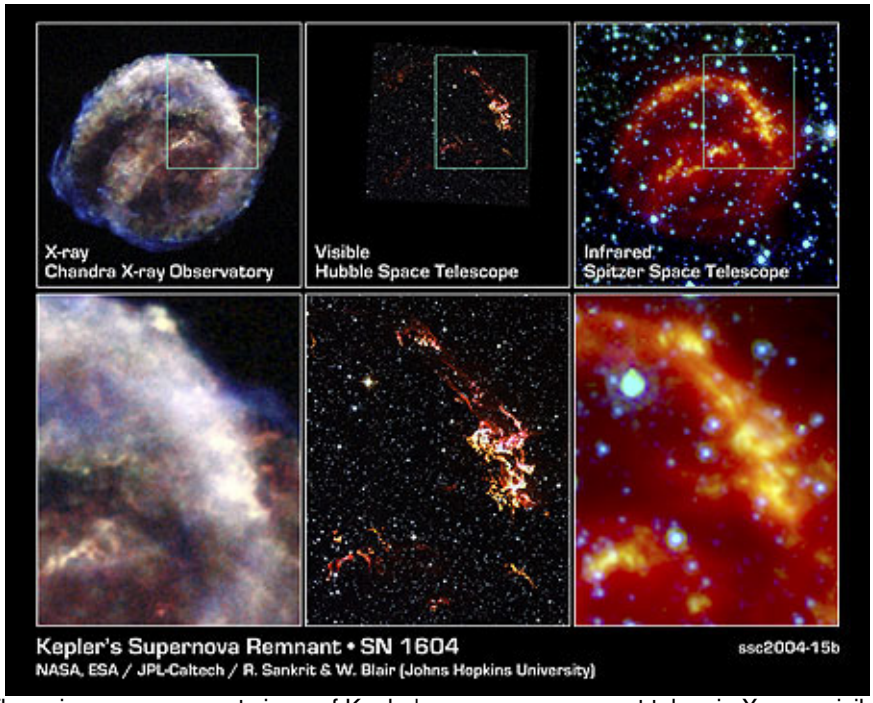
- NASA is committed to the principles of open competition and merit review as a key to excellence. The measurement investigations for the LRO were selected through the competitive AO process.

Key Participants

- The requirements for the Robotic Lunar Exploration program are determined by the Exploration Systems Mission Directorate. Participants are GSFC, LaRC, and KSC.

Theme: The Universe

The Universe



These images represent views of Kepler's supernova remnant taken in X-rays, visible light, and infrared.

President's FY 2006 Budget Request (Dollars in Millions)

The Universe	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	1,351.7	1,513.2	1,512.2	1,531.5	1,539.4	1,495.0	1,406.7
Changes from FY 2005 Request	46.9	68.7	-49.1	-62.5	-68.3	111.6	

Overview: *What* NASA Accomplishes through the The Universe Theme

How did the universe begin? How will it end? Does time have a beginning and an end? The universe is a dynamic, evolving place, governed by cycles of matter and energy. In an intricate series of physical processes, chemical elements are formed and destroyed, passed between stars and diffuse clouds. Through The Universe Theme, NASA seeks to understand these cycles and how they created the unique conditions that support our very existence. Where did we come from? Are we alone? Astronomers search for answers to these questions by looking far away, towards the beginning of time, to see galaxies forming, and close to home, in search of planetary systems like our own around nearby stars.

The Universe suite of operating missions includes 3 Great Observatories, which have helped astronomers unravel the mysteries of the cosmos by allowing contemporaneous observations of objects at different spectral wavelengths. The best known of these is the Hubble Space Telescope, which has literally rewritten astronomy textbooks since its launch in 1990. Hubble was joined by the Chandra X-Ray Observatory in 1999, and the Spitzer Space Telescope in 2003.

In the years to come, new technologies and more powerful instruments will allow the Universe Theme's Beyond Einstein missions to look deeper into the cosmos, taking us to the edge of black holes and nearly to the beginning of time. In our search for origins, we will peer one-by-one at hundreds of our nearest neighbor stars and inventory their planets, searching for solar systems resembling our own with a balmy, wet planet like Earth. We do not yet know whether the worlds we seek are common or exceedingly rare, but our journey has already begun.

Theme: The Universe

Relevance: *Why* NASA conducts The Universe work

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

The Universe Theme seeks to answer questions that humankind has been pondering for millennia: 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 no longer beyond scientists' reach.

Knowing where we come from means understanding how the universe began and how its evolution culminated in everything that can be observed today. Knowing whether Earth alone supports life in the cosmos depends upon NASA's search for life-sustaining planets or moons, and researchers' understanding of the diversity of life here on Earth. Programs within the Universe Theme are aimed at developing the new technologies, building the instruments to make crucial observations, and performing the science that will bring answers to these questions.

Relevance to the NASA mission:

The Universe Theme supports NASA's mission to "explore the universe and search for life" by attempting to understand the origin and evolution of life, searching for evidence of life elsewhere and exploring the universe beyond.

Relevance to education and public benefits:

Over the last decade, few scientific endeavors have provided the world with more spectacular images or yielded more fascinating results than the Universe's Great Observatories: the Hubble Space Telescope, Chandra X-Ray Observatory and Spitzer Space Telescope. As more sophisticated instruments have been added through the years, the world has witnessed the birth of stars, begun to unravel the mysteries of black holes, and looked billions of years into the past. This flood of knowledge and questions has spread across the globe via front-page press, television, Web sites, and school curricula at all levels. Programs within the Universe Theme will continue to make significant contributions toward meeting national goals for the reform of science, mathematics, and technology education, as well as elevating scientific and technological literacy throughout the country.

Performance

Major Activities Planned for FY 2006:

- Keck Interferometer nulling mode becomes available for key project observing.
- Large Binocular Telescope Interferometer (LBTI) will be commissioned.
- Gravity Probe B (GP-B) science results will become available.
- James Webb Space Telescope (JWST) confirmation to enter development phase.

Major Recent Accomplishments:

- The Spitzer Space Telescope penetrated cosmic dust to reveal previously hidden objects: newborn stars, a cannibalistic galaxy, and what may be the youngest planet ever detected.
- NASA launched Gravity Probe-B.
- Hubble Space Telescope's Ultra Deep Field images revealed some of the first galaxies to emerge after the Big Bang.
- NASA launched Swift, a gamma-ray burst explorer.
- Chandra completed five years of observations.

Theme: The Universe

The Universe Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

4. Conduct advanced telescope searches for Earth-like planets and habitable environments around the stars.

4.1 Learn how the cosmic web of matter organized into the first stars and galaxies and how these evolved into the stars and galaxies we see today.

6UNIV17 Successfully demonstrate progress in learning how the cosmic web of matter organized into the first stars and galaxies and how these evolved into the stars and galaxies we see today. Progress toward achieving outcomes will be validated by external expert review.

6UNIV20 Complete James Webb Space Telescope (JWST) Mission Preliminary Design Review (PDR).

4.2 Understand how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life.

6UNIV1 Successfully demonstrate progress in understanding how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life. Progress toward achieving outcomes will be validated by external expert review.

4.3 Learn how gas and dust become stars and planets.

6UNIV2 Successfully demonstrate progress in learning how gas and dust become stars and planets. Progress toward achieving outcomes will be validated by external expert review.

6UNIV18 Complete Stratospheric Observatory for Infrared Astronomy (SOFIA) Airworthiness Flight Testing.

4.4 Observe planetary systems around other stars and compare their architectures and evolution with our own.

6UNIV3 Successfully demonstrate progress in observing planetary systems around other stars and comparing their architectures and evolution with our own. Progress toward achieving outcomes will be validated by external expert review.

4.5 Characterize the giant planets orbiting other stars.

6UNIV4 Successfully demonstrate progress in characterizing the giant planets orbiting other stars. Progress toward achieving outcomes will be validated by external expert review.

4.6 Find out how common Earth-like planets are and see if any might be habitable.

6UNIV5 Successfully demonstrate progress in determining how common Earth-like planets are and whether any might be habitable. Progress toward achieving outcomes will be validated by external expert review.

6UNIV21 Begin Kepler Spacecraft Integration and Test (I&T).

4.7 Trace the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life.

6UNIV6 Successfully demonstrate progress in tracing the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life. Progress toward achieving outcomes will be validated by external expert review.

4.8 Develop the tools and techniques to search for life on planets beyond our solar system.

6UNIV7 Successfully demonstrate progress in developing the tools and techniques to search for life on planets beyond our solar system. Progress toward achieving outcomes will be validated by external expert review.

Theme: The Universe

5. Explore the universe to understand its origin, structure, evolution, and destiny.

5.1 Search for gravitational waves from the earliest moments of the Big Bang.

6UNIV8 Successfully demonstrate progress in searching for gravitational waves from the earliest moments of the Big Bang. Progress toward achieving outcomes will be validated by external expert review.

5.2 Determine the size, shape, and matter-energy content of the universe.

6UNIV9 Successfully demonstrate progress in determining the size, shape, and matter-energy content of the Universe. Progress toward achieving outcomes will be validated by external expert review.

5.3 Measure the cosmic evolution of dark energy.

6UNIV10 Successfully demonstrate progress in measuring the cosmic evolution of dark energy. Progress toward achieving outcomes will be validated by external expert review.

5.4 Determine how black holes are formed, where they are, and how they evolve.

6UNIV11 Successfully demonstrate progress in determining how black holes are formed, where they are, and how they evolve. Progress toward achieving outcomes will be validated by external expert review.

5.5 Test Einstein's theory of gravity and map space-time near event horizons of black holes.

6UNIV12 Successfully demonstrate progress in testing Einstein's theory of gravity and mapping space-time near event horizons of black holes. Progress toward achieving outcomes will be validated by external expert review.

5.6 Observe stars and other material plunging into black holes.

6UNIV13 Successfully demonstrate progress in observing stars and other material plunging into black holes. Progress toward achieving outcomes will be validated by external expert review.

5.7 Determine how, where, and when the chemical elements were made, and trace the flows of energy and magnetic fields that exchange them between stars, dust, and gas.

6UNIV14 Successfully demonstrate progress in determining how, where, and when the chemical elements were made, and in tracing the flows of energy and magnetic fields that exchange them between stars, dust, and gas. Progress toward achieving outcomes will be validated by external expert review.

5.8 Explore the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays.

6UNIV15 Successfully demonstrate progress in exploring the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays. Progress toward achieving outcomes will be validated by external expert review.

6UNIV19 Complete Gamma-ray Large Area Space Telescope (GLAST) Spacecraft Integration and Test (I&T).

5.9 Discover how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies.

6UNIV16 Successfully demonstrate progress in discovering how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies. Progress toward achieving outcomes will be validated by external expert review.

Efficiency Measures

6UNIV22 Complete all development projects within 110% of the cost and schedule baseline.

6UNIV23 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6UNIV24 Peer review and competitively award at least 80%, by budget, of research projects.

6UNIV25 Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days.

Program Management

The Universe Theme Director is Dr. Anne Kinney, Director of The Universe Division, Science Mission Directorate.

Quality

Independent Reviews:

- Each major mission has an independent review team that evaluates the project at critical junctures in the development process. These reviews occur throughout the year.
- NASA asked the National Research Council to review the robotic servicing of the Hubble Space Telescope. Results of the report were released in December 2004 and can be found at the National Academies Web site: http://nationalacademies.org.
- November 2004 - Independent Cost, Schedule & Management Review - determined SOFIA's readiness to proceed with the start of test flights.
  December 2004 - Initial Science Operations Review concluded that SOFIA should move forward with operations, but should modify early science plans.

Program Assessment Rating Tool (PART):

The Universe Theme was previously comprised of 2 themes: Structure and Evolution of the Universe (SEU), and Astronomical Search for Origins (ASO). The SEU Theme was reviewed and received a PART rating of "effective."

OMB found that "SEU is a well-defined, well-managed program with clear purpose and direct ties to NASA's mission. SEU embraces the research priorities of the astronomy and astrophysics community and includes those priorities within its mission plans."

Due to past cost and schedule concerns, OMB has recommended, and NASA wil be implementing, consistent with its new standard cost management policies, the following recommendations:

1) Estimated life cycle cost before entering development
2) Anticipated cost and schedule associated with each mission phase
3) Mission cost and and schedule progress achieved in each phase before entering the next, and
4) Any plans to re-baseline life cycle cost and/or schedule

Theme: The Universe

Budget Detail (Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
The Universe	**1,351.7**	**1,513.2**	**-1.0**	**1,512.2**	
Navigator	165.2	233.7	-34.3	199.4	
James Webb Space Telescope	243.2	311.8	59.8	371.6	
Hubble Space Telescope	242.5	215.7	-25.0	190.7	
Stratospheric Observatory for Infrared Astronomy	66.9	50.9	-2.6	48.3	
Gamma-ray Large Area Space Telescope	102.7	107.0	-7.6	99.4	
Discovery	50.8	125.5	-7.6	117.9	
Explorer	58.4	82.0	18.8	100.8	
Universe Research	363.1	331.6	-15.9	315.7	
International Space Science Collaboration	31.9	13.3	-0.3	13.0	
Beyond Eistein	26.9	41.8	13.7	55.5	

James Webb Space Telescope - Concluding design work and ramping up fabrication to get to preliminary design review.

Navigator - SIM has experienced a 14-month delay to launch resulting from budgetary resolutions made in FY2005.

Discovery - Kepler is the only Discovery project included in the Universe Theme.

Theme: The Universe
Program: Navigator

President's FY 2006 Budget Request

(Dollars in Millions)

Navigator	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	165.2	233.7	199.4	246.6	394.5	432.1	434.1

Overview

Missions in the Navigator program.

Are we alone? For centuries, humankind has pondered this question. Medieval scholars speculated that other worlds must exist, some harboring other forms of life. Within the past few decades, advances in science and technology have brought us to the threshold of finding an answer to this timeless question.

Recent discovery of planets around stars other than the Sun confirms that the solar system is not unique. Indeed, these extrasolar planets appear to be common in the galactic neighborhood. Yet the planets discovered thus far are giants, like Jupiter and Saturn, unlikely to support life. But some of these systems might also contain smaller, terrestrial planets like Mars and Earth.

Over the next 15 years, NASA will embark on a bold series of missions to find and characterize new worlds using the most sensitive instruments ever built. The Keck Interferometer will combine the light of the world's largest optical telescopes, extending NASA's vision to new distances. Using a technique known as interferometry, Keck will study dust clouds around stars where planets may be forming and provide the first direct images of giant planets outside the solar system. The Space Interferometry Mission (SIM) will measure the distances and positions of stars with unprecedented accuracy, allowing researchers to detect evidence of planets just slightly larger than Earth. Finally, the Terrestrial Planet Finder (TPF) will build upon the legacy of the missions that have gone before it. With an imaging power 100 times greater than the Hubble Space Telescope, TPF will send back the first images and atmospheric chemical analyses of nearby planetary systems.

Plans For FY 2006

Keck Interferometer Nulling Mode will become available for key project observing in January 2006.

As a result of an Announcement of Opportunity released during FY 2005, NASA Headquarters will select the science investigations for TPF-C.

SIM cost and schedule baselines will be determined in preparation for the development phase beginning in 2007.

Theme: The Universe
Program: Navigator

Changes From FY 2005

- The TPF project has been divided into two missions: a visible coronagraph to be flown first, followed by an infrared formation flying interferometer.
- SIM launch has slipped approximately two years.
- Cost increases on the SIM instrument and spacecraft have occurred as the design concept has matured and as the project moves toward implementation (when a cost cap is established).

Program Management

JPL - Navigator project management, including mission and science operations.
NASA and JPL Program Management Councils - program responsibility.

Technical Description

The Navigator program consists of a coherent series of increasingly challenging projects, each complementary to the others and each mission building on the results and capabilities of those that preceded it as NASA searches for habitable planets outside of the solar system. As part of the Navigator program's primary mission, Keck Interferometer will characterize inner dust environments around other star systems, and identify long-period planets and "warm-Jupiters," while the LBTI will characterize outer dust environments and observe giant planets. SIM will search for terrestrial planets, characterize planetary systems, and determine planet mass. The TPF missions will find and characterize planets and habitable environments outside the solar system.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Keck Interferometer								Science on Keck is done continuously; 3 capabiities using 2 large telescopes will be developed and tested through 2007. Outrigger telescopes come on line in 2012.	Tech Form Dev Ops Res	 Feb-03	 Feb-23
Large Binocular Telescope Interferometer								Development, Operations, and Research dates determined at Confirmation Review.	Tech Form Dev Ops Res	 Jan-01 Nov-02 Mar-06 Mar-07	 Nov-02 Mar-06 Mar-16 Mar-17
Space Interferometry Mission								Development, Operations, and Research dates will be determined at Non Advocate Review.	Tech Form Dev Ops Res	Oct-98 Aug-03 May-07 Oct-12 Oct-12	Aug-03 May-07 Oct-12 Oct-16 Oct-19
Terrestrial Planet Finder								Detection and characterization of Earth-like planets around as many as 150 stars up to 45 light-years away. TPF is in pre-formulation.	Tech Form Dev Ops Res	Oct-02	Oct-10

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

Strategy For Major Planned Acquisitions

- The Navigator program is a multi-project program. Each project has its own major acquisitions, which can be found on the project information sheets in the Appendix.

Key Participants

- The Navigator program is a multi-project program. Each project has its own key participants, which can be found on the project information sheets in the Appendix.

Risk Management

- RISK: It is possible that a large vacuum chamber for SIM and TPF may not be available in the timeframe necessary to maintain development schedules. MITIGATION: The SIM team is exploring potential available facilities; Navigator Program Office has begun a site evaluation at JPL and is preparing a contract to procure preliminary vacuum chamber designs.
- RISK: If the Keck Interferometer (KI) outriggers are not available, NASA's ability to obtain long-term astrometry may be lost. This would reduce the ability to detect long-period (greater than 20-year orbits), Uranus-sized planets around nearby stars. MITIGATION: At this time, NASA is continuing to work through the National Environmental Policy Act process, which will allow construction of the outriggers on Mauna Kea. If unsuccessful, alternative sites or other ways of obtaining key elements of the science will be considered.
- RISK: The program may fail to accurately predict the dustiness of the exo-solar environment. If the exo-solar environment is dustier than predicted, the TPF instruments will not be designed appropriately to "see" the planets. MITIGATION: The Navigator program will monitor future observations from within and outside the program for data that supports or disproves this concern. Such data comes from LBTI, Keck, Spitzer Space Telescope, and the Very Large Telescope Interferometer (of the European Southern Observatory).

Theme: The Universe
Program: James Webb Space Telescope

President's FY 2006 Budget Request

(Dollars in Millions)

James Webb Space Telescope	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	243.2	311.8	371.6	372.5	328.6	227.0	189.4

Overview

The James Webb Space Telescope (JWST)--identified by the National Research Council as the top priority for astronomy and physics for the current decade--is a large, deployable infrared astronomical space-based observatory. JWST will enter development in 2006 and is scheduled for launch in 2011. The mission is a logical successor to the HST, extending beyond Hubble's discoveries into the infrared, where the highly redshifted early universe must be observed, where cool objects like protostars and protoplanetary disks emit strongly, and where dust obscures shorter wavelengths.

Artist's impression of JWST

During its five-year science mission, JWST will address the questions: "How did we get here?" and "Are we alone?" by exploring 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, assembly of galaxies, origins of stars and planetary systems, and origins of life.

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

Plans For FY 2006

Funds for JWST in 2006 will go toward a wide array of detailed flight design and long-lead procurement and flight hardware fabrication efforts, spanning all elements of the entire observatory, as well as capital expenses on manufacturing, assembly, and test equipment. JWST will undergo its mission-level preliminary design review, and a non-advocate review, which will lead to planned confirmation with formal approval of, and commitment to, full-scale development--a major program milestone.

Mirror segments for JWST's main optic, its primary mirror, will be well into fabrication in 2006. The mirror segments are long-lead schedule items, and the critical path of development runs through primary mirror fabrication and assembly, so this large-scale activity is of paramount importance in FY 2006.

Although JWST will not launch until 2011, construction will be mostly complete by FY 2008. The remaining schedule will be used for assembly, integration and a great deal of testing. Because JWST is a large spacecraft that will operate in extremely cold temperatures in the vacuum of space, large cryogenic vacuum test facilities are required to accommodate it and a great deal of time will be needed to test it. Preparation of large, cryogenic test facilities and equipment will be underway in FY 2006 so they will be ready in time for pathfinder testing with engineering models, and subsequently, flight article testing.

Theme: The Universe
Program: James Webb Space Telescope

Changes From FY 2005

- None.

Program Management

GSFC is responsible for JWST project management. NASA and GSFC Program Management Councils have program oversight responsibility.

Technical Description

In order to provide the resolution and sensitivity required by science investigations, JWST's main optic is 6.5 meters in diameter, and the telescope assembly and scientific instruments must operate at minus 365 degrees Fahrenheit. A tennis court-sized shield shades these components from the Sun, Earth, and Moon, allowing them to radiate their heat to the extreme temperatures of deep space and thereby become very cold themselves. Since the telescope's main optic and the sunshade are too large to fit into the nose cone of any practical rocket, they must be folded up for launch. Once in space, they will unfurl into their operational configuration. JWST will orbit the Sun in tandem with the Earth, around Sun-Earth Lagrange point 2 (L2), which is ideally suited for the observatory's mission.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
JWST								Provide the next generation space telescope to observe the first stars and galaxies; determine the shape and fate of the Universe.	Tech	Apr-96	Apr-99
									Form	Apr-99	Jul-06
									Dev	Aug-06	Aug-11
									Ops	Aug-11	Feb-17
									Res	Mar-12	Feb-18

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

Strategy For Major Planned Acquisitions

- JWST is being built by Northrop Grumman Space Technology, teamed with Ball, Kodak and Alliant Techsystems. Selections were made via a NASA Request for Proposal.
- The Space Telescope Science Institute (STScI) is developing the science and operations center and associated services. STScI was selected by the NASA Administrator.
- The University of Arizona, Tucson, is providing the primary near-infrared science camera. The selection was made via a NASA Announcement of Opportunity.

Key Participants

- The Canadian Space Agency is providing the fine guidance sensor for guiding the pointing of the telescope, as well as operations support.
- The European Space Agency is providing science instrumentation--the near-infrared spectrograph and the optical bench assembly for the mid-infrared instrument--as well as operations support. A launch vehicle and launch services have also been proposed.

Risk Management

- 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 tells us this is likely to occur. MITIGATION: NASA has written clearly-defined interfaces and is actively managing and complying with export controls (ITAR).
- RISK: JWST requires advances in several technologies, which could present cost and schedule problems. However, there is a low possibility that this will occur. MITIGATION: To ensure these technologies are developed and become ready when needed, NASA is aggressively developing large, lightweight cryogenic optics, wavefront sensing and control algorithms, and high-performance detectors.

Theme: The Universe
Program: Hubble Space Telescope

President's FY 2006 Budget Request

(Dollars in Millions)

Hubble Space Telescope	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	242.5	215.7	190.7	218.3	143.2	170.2	95.0

Overview

Since 1990, the HST has used its pointing precision, powerful optics, and state-of-the-art instruments to explore the visible, ultraviolet and near-infrared regions of the electromagnetic spectrum. Until such time that Hubble is no longer able to carry out its scientific mission, the observatory will continue to investigate the formation, structure, and evolution of stars and galaxies, studying the history of the universe, and providing a space-based research facility for optical astronomy.

Hubble Space Telescope in Space

Hubble development funding supports a suite of life extension activities, which will maximize science return as the telescope's capabilities degrade over time. In addition, a robotic spacecraft is under development to be launched on an expendable launch vehicle, rendezvous with HST, and safely deorbit the observatory at the end of its useful science life. While this development activity is underway, modification and upkeep of ground operations systems will continue.

For more information, please see:
http://hubble.gsfc.nasa.gov/index.php

Plans For FY 2006

The HST program will continue operations and observatory life extension efforts, while work is conducted on the robotic deorbit mission. The timing and content of the deorbit mission will be a result of activities conducted in 2005.

Changes From FY 2005

- The Space Telescope Imaging Spectrograph had a failure in the power supply late in 2005 and is no longer operational. Therefore, HST has no high quality spectroscopic capability.
- Life extension activities: 2-gyro pointing to be available in early 2005; 1-gyro ops mode may be possible; battery testing on the flight battery test bed; and other ops and science planning.

Program Management

GSFC is responsible for HST project management. The NASA and GSFC Program Management Councils have program oversight responsibility.

Theme: The Universe
Program: Hubble Space Telescope

Technical Description

Armed with a 2.4-meter primary mirror, the Hubble Space Telescope operates in wavelengths from the near-ultraviolet to the near-infrared. The observatory was designed to be serviced and upgraded by astronauts, and four servicing missions have been carried out since its launch in 1990. Most recently, in 2002, the shuttle crew installed the Advanced Camera for Surveys (ACS) and a cryo-cooler that brought the ailing Near Infrared Camera and Multi-Object Spectrometer (NICMOS) back to life. These instruments continue to allow HST to provide high quality astronomical data for several more years, after which the observatory will be decommissioned.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
HST Operations								Investigate formation, structure & evolution of stars and galaxies, & study the history of the universe in the visible, ultraviolet and near-infrared regions of the electromagnetic spectrum.	Tech Form Dev Ops Res	 Apr-90 Apr-90	 Sep-10 Sep-12
HST Deorbit								Schedule to be determined in greater detail during 2005.	Tech Form Dev Ops Res		

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

Strategy For Major Planned Acquisitions

- The acquisition strategy for development and procurement of the deorbit capability will be determined during 2005.

Key Participants

- The Space Telescope Science Institute in Baltimore, MD is responsible for operation of the telescope.
- The European Space Agency (ESA) has provided instruments, solar panels and other elements of the telescope. They also play a role in operation of the telescope with a contingent at Space Telescope Science Institute. There is also a data center in Europe to support European observers.

Risk Management

- RISK: It is possible that development of rendezvous and docking capability will not be successful. MITIGATION: Alternate technology development plans and activities will be underway or in waiting until the missions succeed or fail. NASA is supporting efforts at the Department of Defense to demonstrate this technology prior to flight.

Theme: The Universe
Program: Stratospheric Observatory for Infrared Astronomy (SOFIA)

President's FY 2006 Budget Request

(Dollars in Millions)

Stratospheric Observatory for Infrared Astronomy (SOFIA)	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	66.9	50.9	48.3	57.1	59.4	60.2	60.4

Overview

SOFIA is an astronomical observatory consisting of a 2.5-meter aperture telescope permanently installed in a specially modified Boeing 747 aircraft. The aircraft, with its open-port telescope provided through a partnership with the German Aerospace Center (DLR), will provide routine access to nearly all of the visual, infrared, far-infrared, and sub-millimeter parts of the spectrum. It will operate from Moffett Federal Airfield in northern California as well as from deployment sites in the southern hemisphere and elsewhere, as dictated by its astronomical targets. SOFIA will serve as a training ground for the next generations of instrument builders well into the 21st century, while producing new instrumentation important to NASA's future space observatories. SOFIA will have an active Education and Public Outreach program, which will include flying educators as well as astronomers.

SOFIA 747 in flight in 1997. Blackout line behind wing is where telescope and door have since been installed.

The SOFIA program extends the range of astrophysical observations significantly beyond those of previous infrared airborne observatories through increases in sensitivity and angular resolution. SOFIA will be used to study many different kinds of astronomical objects and phenomena, including: star birth and death; solar system formation; complex molecules in space; planets, comets, and asteroids in the solar system; nebulae and dust in galaxies; and black holes at the centers of galaxies.

For more information, please see: http://sofia.arc.nasa.gov/

Plans For FY 2006

The program should complete the "airworthiness" portion of the flight test phase, namely, those flights necessary to demonstrate that the modified 747's flight characteristics are as expected under various conditions. Also, the Observatory Performance Testing portion of the flight test phase, to demonstrate the operation of the telescope in observing conditions, will be conducted. NASA will work toward completing flight testing in order to reach the milestone of an Operational Readiness Review by August 2006. If NASA can accomplish this, science operations could potentially begin before the end of 2006.

Changes From FY 2005

- NASA, rather than the Universities Space Research Association (USRA), will directly manage the aircraft maintenance and operations.

Theme: The Universe
Program: Stratospheric Observatory for Infrared Astronomy (SOFIA)

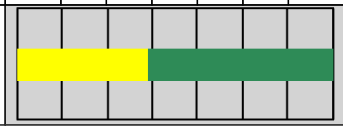
Program Management

ARC - SOFIA project management, including mission and science operations.
NASA and ARC Program Management Councils - program responsibility.

Technical Description

The SOFIA observatory is 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. The SOFIA Science and Mission Operations Center houses facility-class science instruments, principal investigator labs, data archives, science/mission planning systems, the main hangar, and supporting equipment to provide operations at a sustained rate of ~160 flights (960 science hours) per year. Additional science instruments provided under NASA grants are housed at separate institutions.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
SOFIA								Launch	Tech Form Dev Ops Res	 Mar-96 Sep-06 Sep-06	 Aug-06 Oct-21 Oct-21

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

Strategy For Major Planned Acquisitions

- The DLR is providing telescope assembly and support during science operations.
- A call for proposals will be issued annually for observing time.
- Competitions to procure new instruments will be conducted as needed.

Key Participants

- The DLR is providing the telescope assembly and support during operations in exchange for 20 percent of science observation time.
- Universities Space Research Association (USRA) is serving as prime contractor for aircraft modifications, operations center, and aspects of the first five years of operations.
- L3 Communications is USRA's major sub-contractor for aircraft modifications.

Risk Management

- RISK: The efforts necessary to complete FAA certification requirements for safe flight may impact project cost and schedule. MITIGATION: NASA's project team is working closely with the FAA to complete requirements in as timely and cost-effective manner as possible.
- RISK: Observatory performance could fail to meet requirements due to worse than expected cavity environment. The likelihood of this occurring is low to moderate. MITIGATION: For the various aspects of performance (telescope pointing and image quality) that could affect SOFIA once it is conducting science operations, potential corrective measures have been analyzed. Specific mitigation techniques would be applied following characterizations during the flight test phase and early science operations if performance is inadequate.

Theme: The Universe
Program: Gamma-ray Large Area Space Telescope (GLAST)

President's FY 2006 Budget Request

(Dollars in Millions)

Gamma-ray Large Area Space Telescope (GLAST)	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	102.7	107.0	99.4	66.8	24.0	19.3	25.8

Overview

A collaboration with the Department of Energy, France, Italy, Sweden, Japan, and Germany, the Gamma-ray Large Area Space Telescope (GLAST) will improve researchers' understanding of the structure of the universe, from its earliest beginnings to its ultimate fate. By measuring the direction, energy, and arrival time of celestial high-energy gamma rays, GLAST will map the sky with 50 times the sensitivity of previous missions, with corresponding improvements in resolution and coverage. Yielding new insights into the sources of high-energy cosmic gamma rays, GLAST will reveal the nature of astrophysical jets and relativistic flows and study the sources of gamma-ray bursts.

Artist's conception of the GLAST observatory.

GLAST will also provide a new tool for studying how black holes, notorious for pulling matter in, can accelerate jets of gas outward at fantastic speeds. Physicists will be able to observe the effects of subatomic particles at energies far greater than those seen in ground-based particle accelerators and will also gain insights into the puzzling question of how energetic gamma rays are produced in the magnetosphere of spinning neutron stars. Perhaps the biggest return will come from understanding the nature of the high-energy gamma-ray sources that have escaped correlation at other wavelengths and constitute the unidentified bulk of nearly 300 known high-energy sources.

For more information, please see http://glast.gsfc.nasa.gov/

Plans For FY 2006

The Large Area Telescope (LAT) and GLAST Burst Monitor (GBM) instruments are scheduled to complete their stand-alone instrument level Integration and Test (I&T) phases, and be integrated with the spacecraft bus. After integration, the entire observatory will start observatory-level I&T, including vibration and environmental testing. The ground system hardware and software will be completed during this fiscal year and exercised against the observatory during I&T. Payload processing and launch vehicle integration planning and preparations are scheduled for completion.

Changes From FY 2005

- Mission Critical Design Review was delayed due to the rebaseline of the LAT and withdrawal of international partners.

Program Management

GSFC - GLAST project management, including mission and science operations.
NASA and GSFC Program Management Councils - program responsibility.

Theme: The Universe
Program: Gamma-ray Large Area Space Telescope (GLAST)

Technical Description

The primary instrument on GLAST is the LAT, which will collect high-energy cosmic gamma rays with a 50-fold improvement in sensitivity over previous missions. During its planned primary mission of five years in Earth orbit, the telescope will both scan the sky and point at individual objects. The secondary instrument is the GBM, which will detect gamma-ray bursts and immediately send their locations to the ground to alert astronomers to make follow-up observations. Like the LAT, the GBM also has better sensitivity and spatial resolution than its predecessors.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
GLAST								Study the high energy gamma rays from natural particle accelerators throughout the universe.	Tech	Jun-98	Dec-99
									Form	Dec-99	Dec-03
									Dev	Dec-03	May-07
									Ops	May-07	May-12
									Res	Jul-07	Jul-12

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

Strategy For Major Planned Acquisitions

- Spacecraft contractor is General Dynamics/Spectrum Astro, acquired via a blanket procurement through GSFC's Rapid Spacecraft Development Office.
- The primary instrument (LAT) at Stanford University and the secondary instrument (GBM) at MSFC were selected through an Announcement of Opportunity competitive selection in 2000.
- The GSFC Science Support Center will support Guest Observers (GO) and manage annual solicitation for GOs. GSFC Mission Operations Center personnel are provided by contractor set aside procurement.

Key Participants

- Stanford University is the home institution of the principal investigator of the LAT, and they are also providing science support.
- Large Area Telescope development and instrument integration is managed by the Stanford Linear Accelerator Center, a Department of Energy-funded laboratory located on the Stanford University Campus.
- Italy is responsible for assembly of the LAT tracker towers, which form the track imaging system, as well as additional hardware used in the towers. Japan and Italy are providing a portion of LAT silicon strip detectors and science support; France is also providing science support.
- The Naval Research Laboratory, which assembles the Calorimeter for the LAT, environmentally tests the integrated instrument and provides science support.

Risk Management

- RISK: LAT production delays are highly likely due to fabrication and test problems, and delayed vendor orders, as well as contractual issues involving international partners. Significant production delays may affect the observatory Integration and Test (I&T) and launch schedule. MITIGATION: NASA is closely monitoring progress in production, and looking at potential modifications to LAT environmental test and observatory I&T flows to mitigate the impact to launch from further tracker production delays.

Theme: The Universe
Program: Discovery

President's FY 2006 Budget Request

(Dollars in Millions)

Discovery	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	50.8	125.5	117.9	76.5	16.8	13.6	14.5

Overview

In space exploration, the possibilities for discovery are without limits. Even with the vast amount of knowledge gained since exploration of the solar system began, there are still more questions than answers. NASA's Discovery program gives scientists the opportunity to dig deep into their imaginations and find innovative ways to unlock the mysteries of the solar system. It represents a breakthrough in the way NASA explores space, with lower-cost, highly focused planetary science investigations designed to enhance our understanding of the solar system. All completed Discovery missions have achieved ground-breaking science within cost and schedule limitations, each taking a unique approach to space exploration. Discovery is an ongoing program that offers the scientific community the opportunity to assemble a team and design exciting, focused science investigations that complement NASA's larger planetary science explorations.

Artist's impression of Discovery mission focus

Kepler, a Discovery project supporting the Universe Theme, is currently in formulation phase.

With the exception of Kepler, all the other Discovery missions (both selected and future missions) fall under the Solar System Exploration Theme responsibility. Please refer to the Solar System Theme, Discovery Program, for detail information.

Plans For FY 2006

Please refer to the Solar System Theme, Discovery Program, for detail information.

Changes From FY 2005

- Please refer to the Solar System Theme, Discovery Program, for detail information.

Program Management

Discovery program management is delegated to Marshall Space Flight Center. Scientific mission priorities and assignment responsibilities reside HQ.

Technical Description

The Kepler spacecraft will be launched into an Earth-trailing, heliocentric orbit similar to that of the Spitzer Space Telescope. Following a 30-day period during which the photometer and spacecraft are characterized, Kepler begins acquiring its scientific data by continuously and simultaneously observing over 100,000 target stars. It is expected that "hot Jupiters" (giant gas planets) in short period orbits will be identified after the first month of observation.

Strategy For Major Planned Acquisitions

- The Discovery program will solicit proposals for an entire mission, put together by a team comprised of people from industry, small businesses, government and universities, led by a PI.
- With the exception of future missions, to be selected via NASA Announcement of Opportunities, all major acquisitions are in place.

Theme: The Universe
Program: Explorer

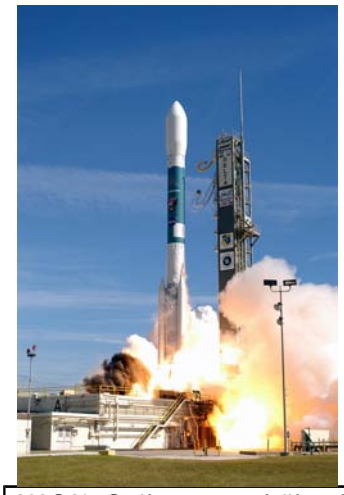
President's FY 2006 Budget Request

(Dollars in Millions)

Explorer	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	58.4	82.0	100.8	76.1	59.4	11.7	9.5

Overview

The Explorer program provides frequent flight opportunities for world-class astrophysics and space physics investigations, utilizing innovative, streamlined and efficient management approaches to spacecraft development and operations. The program (including Future Explorers) is managed within the Earth -Sun Theme, but selected projects are managed under the Universe Theme. The program emphasizes missions that can be accomplished under the control of the scientific research community and seeks to control total mission life-cycle costs. The program also seeks to enhance public awareness of, and appreciation for, space science and to incorporate educational and public outreach activities.



NASA's Swift spacecraft lifts off from Complex 17A, Cape Canaveral Air Force Station aboard a Boeing Delta II ELV.

The Medium-Class Explorers (MIDEX) project provides flight opportunities for focused science missions. MIDEX investigations are characterized by the definition, development, launch service, and mission operations and data analysis costs set with each Announcement of Opportunity (AO). The Small Explorer (SMEX) project provides frequent flight opportunities for highly focused and relatively inexpensive missions. SMEX investigations are characterized by the definition, development, launch service, and mission operations and data analysis costs set within each AO. Mission of opportunity (MO) space flights, conducted on a no-exchange-of-funds basis, are flown as part of a non-NASA space mission.

Explorer projects in the Universe Theme include the Widefield Infrared Survey Explorer (WISE) and others in various stages (see technical description).

Link to the Explorers program homepage for information.
http://explorers.gsfc.nasa.gov/missions

Plans For FY 2006

During FY 2006, spacecraft fabrication will be completed in preparation for integration and testing. Payload development activity will also enter the integration and test phase, including the scan mirror, focal planes, imaging optics, telescope, elsctronics and cryostat.

Program Management

The Explorer program is a multiple-project program with program responsibility assigned to GSFC.

Theme: The Universe
Program: Explorer

Technical Description

The Explorer program MIDEX and SMEX mission strategies can be found in the Earth-Sun System Explorer program technical description.

WISE, a super-cooled infrared telescope designed to survey the entire sky with 1,000 times more sensitivity than previous infrared missions, will study asteroids, the coolest and dimmest stars, and the most luminous galaxies.

The Extreme Universe Space Observatory (EUSO) is an instrument for ESA to study the most energetic particles in the universe. It is a mission of opportunity.

Astro-E2, Japan's fifth X-ray astronomy mission, is being developed at the Institute of Space and Astronautical Science of Japan Aerospace Exploration Agency in collaboration with NASA.

The SWIFT mission, launched in 2004, is dedicated to studying gamma-ray bursts

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Swift								Study the position, brightness, and physical properties of gamma ray bursts.	Tech Form Dev Ops Res	 Feb-01 Feb-05	 Feb-05 Jan-07
WISE								Map sky in infrared light.	Tech Form Dev Ops Res	 Apr-02 Jul-05 Aug-08	 Jul-05 Aug-08 Jul-10

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

Strategy For Major Planned Acquisitions

- Explorer program has established an acquisition strategy that contracts for whole mission (concept through delivery of the science data/analysis). Emphasis will be placed on performance incentives.
- Investigations are selected through the AO process, where multiple investigations are selected for initial concept studies with a competitive down-select to proceed to the next stage of formulation.
- Investigations will be 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.

Key Participants

- Industry, academia, other government agencies, international partners.

Risk Management

- RISK: Implementation of first-of-a-kind space research missions are inherently risky. MITIGATION: Technical, management, and cost risks for each investigation are carefully examined as part of the selection process, and acceptable risks are documented in individual project appendices attached to the Explorer Program Plan. All technical and programmatic risks will be further reviewed as part of the project confirmation review during the PDR timeframe to ensure risks have been mitigated.

Theme: The Universe
Program: Universe Research

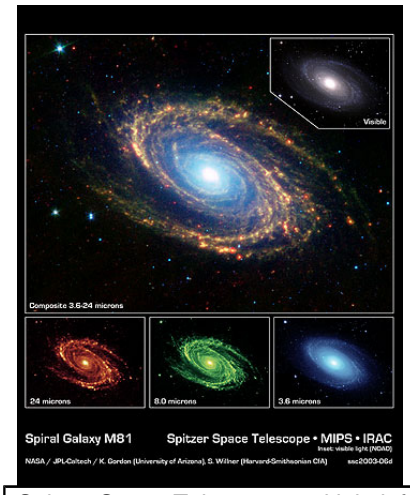
President's FY 2006 Budget Request

(Dollars in Millions)

Universe Research	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	363.1	331.6	315.7	311.5	309.2	302.8	296.4

Overview

For thousands of years, people have gazed at the stars, given them names, and observed their changes. Though NASA has only recently joined the ancient pursuit of knowledge of the cosmos, forty years of space science has yielded such astronomical advances as full-sky mapping of the oldest light in the universe, and discovering that dark energy is accelerating the universe's expansion. Yet many important and perplexing puzzles remain to be solved: How did the universe begin? Where did we come from? Are we alone?



Spitzer Space Telescope multiple infrared views of spiral galaxy Messier 81.

The Universe Theme's Research program strives to answer these questions with a host of operating missions led by investigators from academia and industry, as well as funding grants for basic research, technology development, 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.

For information on current operating missions, go to: http://science.hq.nasa.gov/missions/universe.html

Plans For FY 2006

The Universe Research Program will continue to maintain and provide missionn data to scientists and researchers, including new data from operating missions. Gravity Probe-B will complete its measurements to investigate two extraordinary predictions of Einstein's General Theory of Relativity: how space and time are warped by the presence of Earth (the geodetic effect), and how Earth's rotation drags space-time around with it ("frame-dragging"). Swift will pinpoint 300 gamma ray bursts (GRBs) a year and provide unprecedented information on the position, brightness, and physical properties of these powerful cosmic explosions. Astro-E2, a Japan/U.S. collaboration with a launch scheduled for summer 2005, will perform extremely high resolution X-ray spectroscopy of stars, galaxies, and black holes. Chandra, NASA's X-ray Great Observatory, will continue to perform detailed studies of black holes, supernovas, and dark matter to increase our understanding of the origin, evolution, and destiny of the universe. Spitzer Space Telescope, the largest infrared telescope ever launched into space and NASA's newest Great Observatory, will complete its second year using its state-of-the-art infrared detectors to pierce the dusty darkness enshrouding galaxies, stars, and planet-forming disks around stars.

In January 2005, the Science Mission Directorate will issue the ROSES-05 (Research Opportunities in Space and Earth Science) Omnibus NRA covering all of the planned research solicitations in Earth-Sun System and Space Science for 2005. The ROSES-05 NRA describes the research goals in detail. The FY2006 budget will fund the proposed activities competitively selected.

Theme: The Universe
Program: Universe Research

Changes From FY 2005

- The number of expected new grants will be lower than planned in 2005.
- Astro-E2 launch delayed until no-earlier-than May 2005.
- Funding for the number and duration of expected mission extensions is lower than planned for in 2005.

Program Management

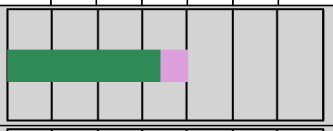
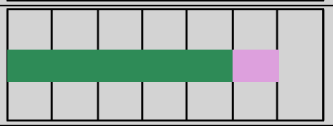
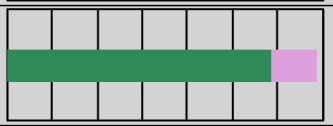
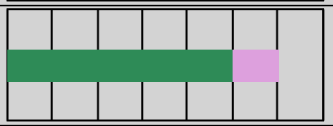
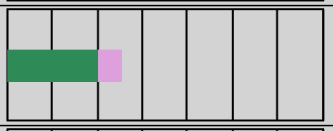
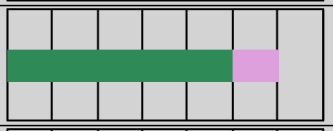
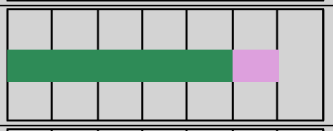
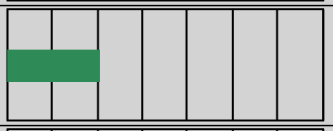
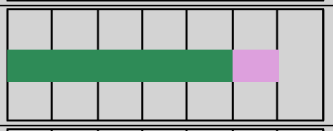
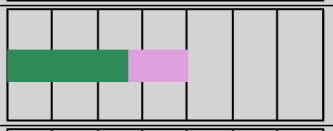
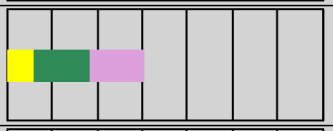
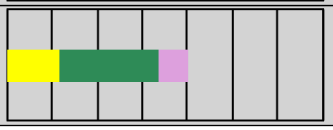
GSFC, JPL and MSFC - project management of current missions.
HQ and Center Program Management Councils - program responsibility.

Technical Description

Spitzer is an IR cryogenic telescope equipped with 3 instruments to study clouds of gas and dust characteristic of star forming regions, the centers of galaxies, and newly forming planetary systems. Chandra's mirrors allow the sharpest X-ray imaging ever achieved. GP-B performs measurements of tiny gravitational effects with 4 ultra-precise spherical gyroscopes supported by unique combination of cryogenics and drag-free satellite technology. With its large field-of-view and high sensitivity, Swift's Burst Alert Telescope computes GRB positions onboard with arc-minute position accuracy; the satellite then slews autonomously to perform follow-up X-ray and optical/UV observations. Astro-E2's US-built microcalorimeter will enable a tenfold improvement in spectral resolution for X-ray studies.

Theme: The Universe
Program: Universe Research

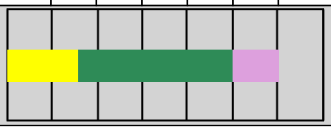
Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
RXTE								Observe the high-energy worlds of black holes, neutron stars, x-ray pulsars, and bursts.	Tech Form Dev Ops Res	 Dec-95 Mar-96	 Feb-07 Sep-07
FUSE								Study physical processes governing the evolution of galaxies as well as the origin and evolution of stars and planetary systems.	Tech Form Dev Ops Res	 Jun-99 Dec-99	 Sep-08 Sep-09
Chandra								Explore the hot, turbulent regions in space with images 25 times sharper than previous x-ray pictures.	Tech Form Dev Ops Res	 Jul-99 Oct-99	 Jul-09 Jul-10
XMM								Conduct sensitive x-ray spectroscopic observations of a wide variety of cosmic sources.	Tech Form Dev Ops Res	 Dec-99 Jun-00	 Sep-08 Sep-09
HETE-2								Carry out a multiwavelength study of gamma ray bursts with ultraviolet, X-ray, and gamma ray instruments.	Tech Form Dev Ops Res	 Oct-00 Feb-01	 Sep-05 Mar-06
WMAP								Probe the early universe by measuring the cosmic microwave background radiation over the full sky.	Tech Form Dev Ops Res	 Jun-01 Oct-01	 Sep-08 Sep-09
INTEGRAL								Unravel the secrets of the highest-energy, most violent phenomena in the universe.	Tech Form Dev Ops Res	 Oct-02 Dec-02	 Sep-08 Sep-09
CHIPS								Study the "Local Bubble" of hot gas surrounding the solar system.	Tech Form Dev Ops Res	 Jan-03 Apr-03	 Sep-05 Sep-05
GALEX								Explore the origin and evolution of galaxies and the origins of stars and heavy elements.	Tech Form Dev Ops Res	 Apr-03 Jun-03	 Sep-08 Sep-09
Spitzer								Study the formation of stars, galaxies, and planets via spectroscopy, high-sensitivity photometry, and imaging.	Tech Form Dev Ops Res	 Aug-03 Oct-03	 May-06 Sep-07
GP-B								Verify certain extraordinary predictions of Einstein's Theory of General Relativity.	Tech Form Dev Ops Res	 Apr-04 Aug-04	 Apr-04 Jul-05 Sep-06
Swift								Study the position, brightness, and physical properties of gamma ray bursts.	Tech Form Dev Ops Res	 Nov-04 Apr-05	 Nov-04 Jan-07 Sep-07

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

Theme: The Universe
Program: Universe Research

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Astro-E2								Study black holes, neutron stars and quasars to unravel the physics high-energy processes and the behavior of matter under extreme conditions.	Tech Form Dev Ops Res	 May-05 Dec-05	 Apr-05 Sep-08 Sep-09

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

Strategy For Major Planned Acquisitions

- Orbital Sciences provides operational support for GALEX; Northrop Grumman provides technical support for Chandra; operational support contracts exist with six major universities across the Nation.
- The prime contractor for Chandra operations is the Smithsonian Astrophysical Observatory (SAO) in Cambridge, MA. The contract for Chandra was renewed in 2003 for a period of five years.
- Lockheed Martin in Bethesda, MD maintains the servicing contract for Hubble Space Telescope and some mission operation servicing for Spitzer Space Telescope.

Key Participants

- SAO operates Chandra.
- Multiple international agreements are in place for operating missions.
- Staff at many universities across the Nation propose and win grants to participate in the Universe Theme operational missions as principal investigators for observation and data analysis, as well as in the Universe Research program.

Risk Management

- RISK: There is a low to moderate likelihood of loss of pointing and control functions on the spacecraft. MITIGATION: NASA incorporates a rigorous personnel training program for early detection and recovery from operational anomalies.

Theme: The Universe
Program: International Space Science Collaboration

President's FY 2006 Budget Request

(Dollars in Millions)

International Space Science Collaboration	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	31.9	13.3	13.0	22.2	39.8	38.4	34.1

Overview

Herschel and Planck, two projects in the International Space Science Collaboration (SSC) Program, are European Space Agency (ESA)-led missions. They will be launched together on an Ariane-5 and then separate while being injected into their transfer orbits. The spacecraft will then proceed independently to their operational orbits.

Herschel's Primary Mirror

Herschel has been designed to unveil a face of the early universe that has remained hidden until now. Thanks to its ability to detect radiation at far-infrared and sub-millimeter wavelengths, Herschel will observe dust obscured and cold objects that are invisible to other telescopes. Targets for Herschel will include clouds of gas and dust where new stars are being born, disks out of which planets may form, and cometary atmospheres packed with complex organic molecules. Herschel's major challenge will be discovering how the first galaxies formed and how they evolved to give rise to present day galaxies as our own. NASA is participating in two of the three instruments.

For more information go to: http://sci.esa.int/science-e/www/area/index.cfm?fareaid=16

Planck will help provide answers to one of the most important sets of questions asked in modern science: how did the universe begin, how did it evolve to the state we observe today, and how will it continue to evolve in the future? Planck's objective is to analyze, with the highest accuracy ever achieved, the remnants of the radiation that filled the universe immediately after the Big Bang (which we observe today as the Cosmic Microwave Background, or CMB). NASA is participating in both instruments.

For more information, see http://sci.esa.int/science-e/www/area/index.cfm?fareai

Plans For FY 2006

NASA will continue to support instrument integration and testing for Herschel and Planck in Europe.

Changes From FY 2005

- In 2004, ESA announced a six-month launch delay, which is reflected in Herschel and Planck out-year budgets.
- Technical difficulties in the development of flight hardware for Herschel resulted in cost increases.

Theme: The Universe
Program: International Space Science Collaboration

Program Management

JPL is responsible for Herschel and Planck project management. NASA and JPL's Program Management Council have program oversight responsibility.

Technical Description

Herschel will be the first observatory to cover the full far-infrared and sub-millimeter waveband and its telescope will have the largest mirror ever deployed in space. It will be 1.5 million km away from Earth. A 3.5 meter mirror will collect light from distant and poorly known objects millions of light years away and focus it onto 3 instruments with detectors kept at temperatures close to absolute zero. Planck will collect and characterize radiation from the CMB using sensitive radio receivers operating at very low temperatures. The receivers will determine the black body equivalent temperature of the background radiation and be capable of distinguishing temperature variations of about one microkelvin. The measurements produce the best ever maps of aniosotopies in CMB radiation field.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Herschel								Help solve the mystery of how stars and galaxies were born.	Tech		
									Form	Sep-97	Sep-01
									Dev	Oct-01	Jul-07
									Ops	Aug-07	Aug-11
									Res	Feb-08	Feb-13
Planck								Analyze remnants of the cosmic microwave background.	Tech		
									Form	Sep-97	Sep-01
									Dev	Oct-01	Jul-07
									Ops	Aug-07	Feb-09
									Res	Feb-08	Feb-10

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

Strategy For Major Planned Acquisitions

- Herschel and Planck are ESA missions. NASA is providing critical components and technologies to this mission.

Key Participants

- Herschel and Planck are ESA missions. NASA is providing critical components and technologies to this mission.

Risk Management

- RISK: Potential launch delays due to ESA spacecraft and instrument schedule issues. MITIGATION: NASA will deliver U.S.-developed hardware (instrument components) as soon as flight units have been built and tested.
- RISK: It is possible that flight hardware will be damaged during integration and testing prior to launch. MITIGATION: NASA is building spare components for the critical pieces of the flight hardware.

Theme: The Universe
Program: Beyond Einstein

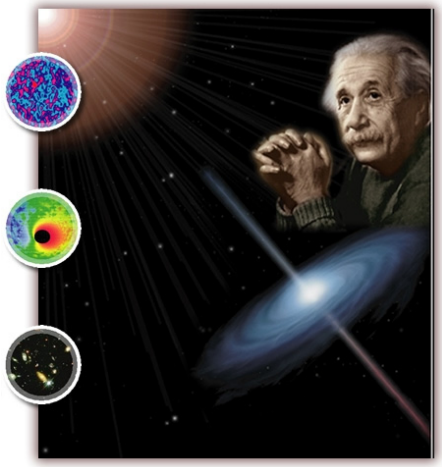
President's FY 2006 Budget Request

(Dollars in Millions)

Beyond Einstein	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	26.9	41.8	55.5	83.9	164.5	219.6	247.4

Overview

In attempting to understand & explain the universe, Albert Einstein devised several theories along with his Theory of General Relativity. Some fantastic predictions flow from these theories: the Big Bang, black holes, and the existence of a "dark energy" currently blowing the universe apart. However, Einstein's theories only predict these things, they do not really explain them. To find answers, scientists have to move beyond theory; they must employ new techniques, and launch missions to observe the universe in new and advanced ways. They must test and validate these new theories and enjoin heretofore separate fields like astronomy and particle physics.



Albert Einstein's theories allow for predictions...but not answers!

Beyond Einstein (BE) flagship missions are the Laser Interferometer Space Antenna (LISA) & Constellation-X (Con-X). LISA, a joint effort NASA/ESA effort, will be the first space-based gravitational wave observatory. LISA will study the death spirals of stars, colliding black holes, and echoes from the universe all the way back to the Big Bang. Con-X will be a combination of several separate spacecraft working in unison as 1 giant X-ray telescope far more powerful than any previous. Con-X will investigate black holes, galaxy formation, the evolution of the universe on the largest scales, the recycling of matter and energy, and the nature of "dark matter." BE will eventually include three Einstein Probe missions: 1)Dark Energy Probe, to study the nature of dark energy that dominates the universe; 2) Black Hole Finder Probe, to survey the universe for black holes; and 3)Inflation Probe, to search for the imprint of gravitational waves from inflation in the polarization of the CMB.

http://universe.nasa.gov

Theme: The Universe
Program: Beyond Einstein

Plans For FY 2006

The focus in 2006 will be progressive concept and technology development on LISA and Con-X. NASA will also proceed with advanced studies on the Einstein Probes, particularly the Dark Energy Probe, also known as the Joint Dark Energy Mission (JDEM, a joint activity of NASA and DoE).

The first priority of formulation is to develop the technologies required to enable the missions in the program. Only after a significant amount of technology advancement toward each mission's requirements is accomplished can the full spectrum of design challenges and detailed costs and schedules be determined. Therefore, significant technology development efforts will be in full swing in 2006, particularly for the LISA mission.

Aside from managing its own technology developments, the LISA mission is leveraging the Space Technology-7 (ST-7) mission under the separate New Millenium program. The ST-7 program is developing the crucial disturbance reduction system technology for application to future missions, among them LISA. ST-7 is not a separate spacecraft but rather a payload flying on the ESA/LISA Pathfinder mission. LISA will advance working relationships between NASA and ESA via collaboration on the LISA Pathfinder mission.

Changes From FY 2005

- Beyond Einstein Formulation Authorization Document signed on October 1, 2004.
- International roles and responsibilities were tentatively established by NASA and ESA for the LISA mission, enabling further mission definition and planning to proceed.

Program Management

GSFC - BE project management, including mission and science operations.
NASA and GSFC Program Management Councils - program responsibility.

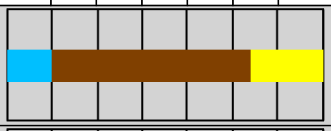
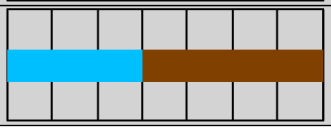
Technical Description

LISA will have three spacecraft flying 5 million kilometers apart in a triangular formation, orbiting the Sun in an Earth-trailing orbit with each carrying pairs of cubic reference masses. Disturbance reduction technology is used to isolate the reference masses and laser interferometry technology is used to measure the relative positions of the reference masses aboard each spacecraft.

Con-X will have four nearly identical spacecraft, each carrying a 1.6-meter telescope comprised of advanced X-ray telescope optics and instruments to analyze X-ray emissions from some of the most violent and bizarre events occurring in the universe.

Theme: The Universe
Program: Beyond Einstein

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
LISA								LISA recently went into formulation. Schedule for development, operations and research will be determined during this time. Goal is to launch sometime within the next decade.	Tech Form Dev Ops Res	Oct-00 Oct-04 Mar-09	Sep-04 Mar-09 Sep-13
Constellation-X								Con-X is currently in pre-formulation. A schedule for development, operations and research is being determined. Goal is to launch sometime within the next decade.	Tech Form Dev Ops Res	Oct-00 Oct-06	Oct-06 Oct-11

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

Strategy For Major Planned Acquisitions

- Beyond Einstein will acquire goods and services through competitive procurements. Implementation details are being developed as part of mission formulation activities.

Key Participants

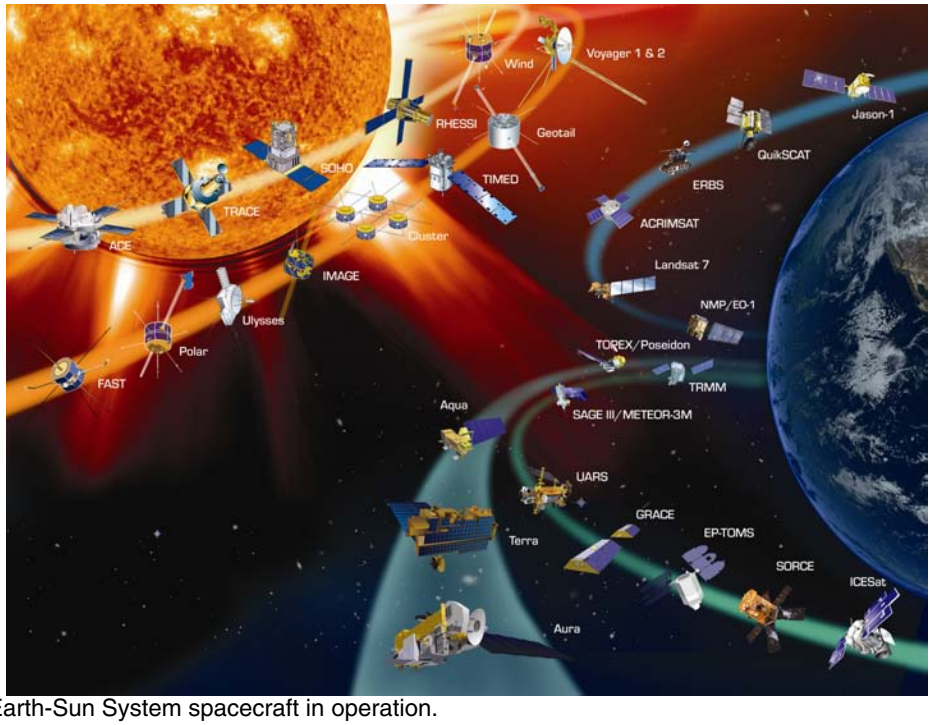
- Con-X partnerships are yet to be determined.
- There is a planned partnership with the Department of Energy on the Einstein Probes Dark Energy mission.
- LISA is an international partnership with ESA, currently operating under a Letter of Agreement.

Risk Management

- RISK: LISA has risks associated with funding and decision-making at ESA that are outside of NASA's control, as well as significant risk associated with management of, and compliance with, export controls (ITAR). It is likely that these issues will surface. MITIGATION: NASA is establishing agreements between agencies early to clarify roles and responsibilities.
- RISK: Technology readiness schedule: LISA requires disturbance reduction technology and ultra-precision laser interferometry technology; Con-X is working on lightweight, low-cost, high-rate production of precision X-ray optics. It is possible that delays will occur, especially if these never-before-achieved technologies do not mature as quickly as expected. MITIGATION: NASA is executing plans to develop key enabling technologies. Plans include progress criteria and milestones that will enable NASA to measure progress and ensure adequate technology maturity in time for design, build and launch.
- RISK: The Joint Dark Energy Mission has risks associated with funding and decision-making at DoE that are outside of NASA's control. MITIGATION: NASA is establishing agreements between agencies early to clarify roles and responsibilities.

Theme: Earth-Sun System

Earth-Sun System



Earth-Sun System spacecraft in operation.

President's FY 2006 Budget Request (Dollars in Millions)

Earth-Sun System	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	2,338.6	2,155.8	2,063.6	2,081.2	2,132.1	2,359.0	2,324.8
Changes from FY 2005 Request	-30.0	-75.5	-107.4	-74.0	-169.2	-165.8	

Overview: *What* NASA Accomplishes through the Earth-Sun System Theme

We live in the extended atmosphere of an active star. Life on Earth's biosphere prospers through a climate powered by energy from the Sun which is moderated by water and carbon cycles. We are protected from the harshness of space by Earth's enveloping magnetic field and an atmosphere. The Earth-Sun System (ESS) Theme is comprised of research programs to understand how the Earth system is changing, to probe the connections between the Sun, Earth and the rest of the solar system, and to discern the consequences for life on Earth. Working with the Agency's domestic and international partners, NASA provides accurate, objective scientific data and analyses to advance understanding of Earth-Sun system processes and phenomena. This advanced understanding enables improved prediction and response capabilities for climate, weather, natural hazards, and even human-induced disasters. NASA is exploiting and expanding a constellation of over 28 Earth-Sun observing satellites routinely making measurements with over 100 remote sensing instruments.

NASA has defined two strategic objectives within the Earth-Sun System Theme: (1) conduct a program of research and technology development to advance Earth observation from space, improve scientific understanding, and demonstrate new technologies with the potential to improve future operational systems; and (2) explore the Sun's connection to the Solar System to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by human explorers, and demonstrate technologies with the potential to improve future operational systems.

Theme: Earth-Sun System

Relevance: *Why* NASA conducts Earth-Sun System work

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

The ESS Theme contributes to three Presidential initiatives: Climate Change Research, Global Earth Observation, and the Vision for Space Exploration. NASA is on the verge of establishing predictive capabilities for the Earth-Sun system that will enable advanced assessments of the causes and consequences of global change and solar variability. NASA is working with partner organizations to apply NASA's science results to help improve the Nation's observational and forecasting systems. These improvements will enhance scientists' ability to manage coastal environments, agriculture and water resources, and aviation safety; monitor air and water quality, forest fires, and the impacts of infectious diseases and invasive species; and conduct hurricane forecasting and disaster relief efforts. In addition, space weather effects may modify the ozone layer, change the propagation of radio and radar signals in and through the ionosphere, disturb navigation, communication, and energy transmission systems on Earth, and produce significant effects on any spacecraft or person outside the atmosphere. Increasing our understanding of Earth and solar variability will improve quality of life, enhance economic stewardship, lower the risk of failure or degraded performance of exploration missions, and enhance U.S. industry's competitiveness in the global marketplace.

Relevance to the NASA mission:

The ESS Theme supports NASA's mission to understand and protect Earth by increasing understanding and enabling prediction of global change and solar variability. It also supports exploration of the universe and search for life by helping understand the space environment through which spacecraft and humans will travel.

Relevance to education and public benefits:

The ESS Theme increases public awareness and understanding of the impacts of global change and solar variability and enables the use of science information in teaching and learning at all levels of education. Through the ESS Theme, NASA seeks to increase science literacy and focus attention on the dynamic Earth and the active Sun, thereby making new scientific knowledge available for use in everyday decisions by the public, businesses, and governments in those areas influenced by environmental changes. Nasa's partnership with educational and service-provider organizations shares the discoveries and knowledge from NASA Earth-Sun missions and research programs to make this new knowledge available to the Nation. The ESS Theme has significant science results to share with the public. The public is informed through news releases highlighting Earth- and solar-related events, dynamic media delivery bringing the excitement of ESS science and research to the public, documentaries, innovative planetarium shows, exhibits at museums and science centers, and content-rich Web sites.

Performance

Major Activities Planned for FY 2006:

- Retrieve/distribute scientific data from Cloudsat and Calipso.
- Continue development of Orbiting Carbon Observatory and Aquarius.
- Ready Solar Dynamics Observatory and NPP for launch.
- Launch STEREO.

Major Recent Accomplishments:

- The Aura launch completed the first series of Earth Observing System satellites.
- SOHO measured the most powerful coronal mass ejections ever recorded.
- GRACE mapped changes in water content of underground aquifers.

Theme: Earth-Sun System

Earth-Sun System Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

14. Advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities including those with the potential to improve future operational systems.

14.1 Transfer 30 percent of NASA developed research results and observations to operational agencies.

6ESS1 For current observations, reduce the cost of acquiring and distributing the data stream to facilitate adoption by the operational community.

6ESS20 Systematically continue to transfer research results from spacecraft, instruments, data protocols, and models to NOAA and other operational agencies as appropriate.

14.2 Develop and deploy advanced observing capabilities to help resolve key Earth system science questions.

6ESS3 Keep 90% of the total on-orbit instrument complement functional throughout the year.

6ESS4 Mature two to three technologies to the point they can be demonstrated in space or in an operational environment and annually advance 25% of funded technology developments one Technology Readiness level (TRL).

6ESS22 Complete Global Precipitation Mission (GPM) Confirmation Review.

6ESS23 Complete Operational Readiness Review for the NPOESS Preparatory Project (NPP).

14.3 Develop and implement an information systems architecture that facilitates distribution and use of Earth science data.

6ESS5 Increase the number of distinct users of NASA data and services.

6ESS6 Improve level of customer satisfaction as measured by a baselined index obtained through the use of annual surveys.

14.4 Use space-based observations to improve understanding and prediction of Earth system variability and change for climate, weather, and natural hazards.

6ESS7 Demonstrate progress that NASA-developed data sets, technologies and models enhance understanding of the Earth system leading to improved predictive capability in each of the six science focus area roadmaps. Progress toward achieving outcomes will be validated by external review.

6ESS21 Benchmark the assimilation of observations and products in decision support systems serving applications of national priority. Progress will be evaluated by the Committee on Environmental and National Resources.

15. Explore the Sun-Earth system to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by human explorers, and demonstrate technologies that can improve future operational systems.

15.1 Develop the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect Earth.

6ESS8 Successfully demonstrate progress in developing the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect the Earth. Progress toward achieving outcomes will be validated by external expert review.

6ESS16 Successfully launch the Solar Terrestrial Relations Observatory (STEREO).

15.2 Specify and enable prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere.

6ESS9 Successfully demonstrate progress in specifying and enabling prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere. Progress toward achieving outcomes will be validated by external expert review.

15.3 Understand the role of solar variability in driving space climate and global change in Earth's atmosphere.

6ESS10 Successfully demonstrate progress in understanding the role of solar variability in driving space climate and global change in the Earth's atmosphere. Progress toward achieving outcomes will be validated by external expert review.

6ESS17 Complete the Solar Dynamics Observatory (SDO) spacecraft structure and begin Integration and Test (I&T).

15.4 Understand the structure and dynamics of the Sun and solar wind and the origins of magnetic variability.

6ESS11 Successfully demonstrate progress in understanding the structure and dynamics of the Sun and solar wind and the origins of solar variability. Progress toward achieving outcomes will be validated by external expert review.

6ESS19 Publish Solar Sentinels Science Definition Team Report.

15.5 Determine the evolution of the heliosphere and its interaction with the galaxy.

6ESS12 Successfully demonstrate progress in determining the evolution of the heliosphere and its interaction with the galaxy. Progress in achieving outcomes will be validated by external expert review.

15.6 Understand the response of magnetospheres and atmospheres to external and internal drivers.

6ESS13 Successfully demonstrate progress in understanding the response of magnetospheres and atmospheres to external and internal drivers. Progress in achieving outcomes will be validated by external expert review.

6ESS18 Initiate Geospace ITM (Ionospheric and Thermospheric Mapper) Phase A studies.

15.7 Discover how magnetic fields are created and evolve and how charged particles are accelerated.

6ESS14 Successfully demonstrate progress in discovering how magnetic fields are created and evolve and how charged particles are accelerated. Progress in achieving outcomes will be validated by external expert review.

15.8 Understand coupling across multiple scale lengths and its generality in plasma systems.

6ESS15 Successfully demonstrate progress in understanding coupling across multiple scale lengths and its generality in plasma systems. Progress in achieving outcomes will be validated by external expert review.

Efficiency Measures

6ESS24 Complete all development projects within 110% of the cost and schedule baseline.

6ESS25 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6ESS26 Peer review and competitively award at least 80%, by budget, of research projects.

6ESS27 Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days.

Theme: Earth-Sun System

Program Management

The Earth-Sun System Theme Director is Dr. Mary Cleave, Director, Earth-Sun System Division, Science Mission Directorate.

Quality

Independent Reviews:

- NASA Advisory Council (NAC) - Review science strategy and implementation strategy for Earth -Sun Systems programs.
- National Research Council - Decadal survey of effectiveness and quality of the Earth-Sun Systems programs

Program Assessment Rating Tool (PART):

OMB has not yet conducted a PART review of the newly formed Earth-Sun System Theme.

The previous Earth System Science Theme was subject to PART review and received a "moderately effective" rating. The assessment found that this program has been successful in demonstrating the use of remotely sensed data to improve our understanding of Earth's processes and that there remains a need to demonstrate a clear methodology and rationale for prioritizing future missions and research. A key opportunity to increase effectiveness lies in improving ability to exploit research results and transition key data sets and technologies to other federal agencies.

The previous Sun-Earth Connection (SEC) Theme was also subject to PART review and was rated "effective." The assessment found that SEC is a well-defined, well-managed program with clear purpose and direct ties to NASA's mission. Furthermore, the assessment concluded that SEC missions have the potential to provide basic understanding and monitoring of the Sun's impact on human and robotic explorers in fulfillment of the Vision for Space Exploration.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Earth-Sun System	**2,338.6**	**2,155.8**	**-92.3**	**2,063.6**	
Earth Systematic Missions	208.3	300.5	-118.5	181.9	
Living with a Star	126.4	202.5	31.5	234.0	
Solar Terrestrial Probes	157.5	100.3	-21.5	78.8	
Explorer Program	128.7	103.6	13.5	117.1	
Earth System Science Pathfinder	114.3	107.9	27.6	135.5	
Earth-Sun System Multi-Mission Operations	414.9	334.3	-66.0	268.3	
Earth-Sun Research	927.4	818.6	26.5	845.1	
Applied Sciences	30.3	43.5	8.6	52.2	
Education and Outreach	23.8	22.9	0.3	23.3	
Earth-Sun Technology	207.0	121.8	5.6	127.4	

Earth Systematic Missions: Glory descope and NPP phase down to launch.
LWS: Geospace Missions staffing up.
Earth-Sun Research: GSFC building support and increase in Aura operations.
Earth System Pathfinders: OCO and Aquarius project ramp up.
STP: Ramp down of Stereo.
Multi-Mission Ops: Funding redistributed to operational projects.

Theme: Earth-Sun System
Program: Earth Systematic Missions

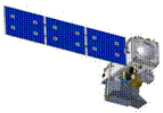
President's FY 2006 Budget Request

(Dollars in Millions)

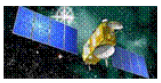
Earth Systematic Missions	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	208.3	300.5	181.9	165.7	198.8	240.8	162.7

Overview

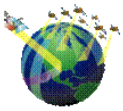
Earth Systematic Missions provide Earth observing satellites that contribute to the provision of long-term environmental data sets that can be used to study the evolution of the Earth system on a range of temporal scales. This information is used to analyze, model, and improve understanding of the Earth system. Data gathered by these spacecraft will enable improved predictions of climate, weather, and natural hazards. NASA works with the science community to identify questions on the frontiers of science that have profound societal importance, and to which remote sensing of Earth can make a defining contribution. These science questions become the foundation of a research strategy that defines requirements for scientific observations from the vantage point of space. Each science focus area has an implementation roadmap that shows what role space-based observations play in meeting overall science objectives. This effort also provides capabilities that can be employed to predict climate, weather, and natural hazards on planets we plan to explore. This program supports Objective 14 and APGs 6ESS25,6ESS20,6ESS22, and 6ESS23.



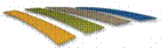
NPOESS Preparatory Project (NPP)



Ocean Surface Topography Mission (OSTM)



Global Precipitation Measurement (GPM)



Landsat Data Continuity Mission (LDCM)

Earth Systematic Missions in Development

For more information, please see
http://science.hq.nasa.gov/missions/earth-sun.html

Plans For FY 2006

The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) will be going through the final stages of integration and testing of the instruments with the spacecraft, and will be conducting major milestone reviews such as Mission Readiness Review and Pre-Environmental Review. The Landsat Data Continuity Mission (LDCM) will be in implementation. The engineering effort will be developing critical design details based on preliminary design specifications with a Critical Design Review as the major milestone review. The Global Precipitation Mission (GPM) will be completing formulation. The engineering effort will be developing preliminary design details based on top level system requirements with a Preliminary Design Review major milestone review followed soon after by the Mission Confirmation Review (the review milestone at which the project receives approval to begin implementation). The Ocean Surface Topography Mission (OSTM) will be completing that part of the implementation phase where hardware and software are developed and then enter into integration and testing.

Theme: Earth-Sun System
Program: Earth Systematic Missions

Changes From FY 2005

- The LDCM budget assumes NASA responsibility to provide two Operational Land Imager (OLI) Instruments (the second OLI will be delivered 2 years after the first) for delivery to NPOESS
- Glory - Assumes instrument build only (requires flight opportunity.
  GPM - Assumes NASA purchasing spacecraft from industry through the Rapid Spacecraft Development Office
- OSTM - Replan of Mission Confirmation Review by 8 months to April 2005 and launch to April 2008

Program Management

Project Management: GSFC: NPP, LDCM, Glory, GPM; JPL: OSTM. The NASA and GSFC/JPL Program Management Councils have program oversight responsibility.

Technical Description

NPP has 4 instruments and a 5 year mission life. It provides continuation of Earth Observing System (EOS) global change observations, and risk reduction demonstration and validation for critical NPOESS instruments. The two LDCM instruments each have a 7 year life, measures land use/cover change for research and serves as a primary observation source for various interests of the United States. GPM, which has 3 instruments and a 3 year mission life, provides a measurement of global precipitation, improving understanding of the Earth's water cycle and capabilities for predicting climate change, weather, natural disasters and water resources. OSTM, which has 6 instruments and a 3 year mission life, provides measurement of sea surface height and is a bridge to an operational mission

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
NPP								Extend key environmental measurements in support of long-term monitoring of climate trends and global biological productivity.	Tech Form Dev Ops Res	 Mar-00 Nov-06	 Oct-06 Nov-11
GPM								Build upon the Tropical Rainfall Measuring Mission (TRMM) to initiate the measurement of global precipitation, a key climate factor.	Tech Form Dev Ops Res	 Oct-04 Feb-06 Jul-10	 Jan-06 Jun-10 Jul-13
OSTM								Measure sea surface height every ten days. Sea surface topography has numerous applications important to global environmental applications (e.g., predicting hurricane intensification).	Tech Form Dev Ops Res	 Oct-04 Apr-05 Apr-08	 Apr-05 Apr-08 Apr-11
Glory								Provide measurements that are critial in studies to understand the Sun, its direct and indirect effect on the Earth system, and its influence on humankind.	Tech Form Dev Ops Res	 Oct-03 Jun-05	 May-05 Jan-08
LDCM								Continue the global land cover data set with provision of synoptic, repetitive multispectral, high-resolution, digital imagery of Earth's land surfaces.	Tech Form Dev Ops Res	 Apr-02 Feb-06	 Jul-06 Dec-08

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

Strategy For Major Planned Acquisitions

- LDCM instruments: full and open competition
- 4 OSTM instruments: AMR, WSOA (optional) are JPL in-house builds. GPSP and LRA are full and open competition
- 2 of the 3 GPM instruments, spacecraft and ground system: full and open competition

Key Participants

- NOAA/IPO - provides 3 of 4 instruments and ground system for NPP, and provides spacecraft and ground system for LDCM
- USGS - provides data processing/distribution and instrument control system for LDCM
- CNES - provides spacecraft and 2 instruments for OSTM
- JAXA - provides dual frequency precipitation radar (1 of the 3 instruments) and launch vehicle for GPM

Risk Management

- RISK: NPP: If instruments are not delivered in accordance with agreed-upon dates, then serious observatory integration and test delays may be realized. There is a very high likelihood that this risk will cause cost increases and a schedule impact of 6 months. MITIGATION: NPP: The NASA and NOAA/IPO team are working together to identify further work-arounds to minimize schedule impacts.
- RISK: LDCM: If Landsat 7 ceases operation before Landsat Continuity Data Mission initial operational capability, then a Landsat data gap will occur. This risk has a very high likelihood and may cause major programmatic and cost impact (data from other sources may be required at higher cost) to the Landsat data user community. MITIGATION: LDCM: NASA will work with USGS and representatives from other affected groups to identify an approach, using existing and near-term resources, that will lessen the impact of a loss of data.

Theme: Earth-Sun System
Program: Living with a Star

President's FY 2006 Budget Request

(Dollars in Millions)

Living with a Star	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	126.4	202.5	234.0	241.0	225.3	292.0	294.8

Overview

The Sun has a period of maximum activity about every 11 years and short-term variability throughout its cycle that generates increased amounts of emitted particles and radiation. The Sun's activity couples with the heliosphere and planetary atmospheres to form a dynamic system. Changes to this system, or space weather/space climate, may induce climate shifts, modify the ozone layer, change communications/radio/radar signals, and produce effects on spacecraft or persons outside Earth's atmosphere. The Living With a Star (LWS) program seeks to understand how and why the Sun varies, how Earth and other planets respond, and how the variability and response affect humanity. Achieving these goals will enable a reliable space weather prediction so undesirable space weather effects can be accommodated or mitigated before they occur. LWS has a 3-part systems approach: a network of research spacecraft, targeted grants, and space weather effects investigations. Program supports the following annual performance goals 6ESS8 and 6ESS10.

Living With a Star logo

For more information, please see:
http://lws.gsfc.nasa.gov.

Plans For FY 2006

Complete the Solar Dynamics Observatory (SDO) spacecraft structure and start integration and testing.
Initiate the Geospace Mission Ionosphere-Thermosphere Mapper Phase A Studies.
Publish Solar Sentinels Science Definition Team report.

Changes From FY 2005

- Start of Phase-A for Geospace Missions delayed one year.

Program Management

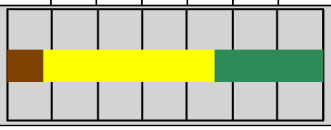
GSFC is the managing Center for the program, individual missions are implemented by GSFC or Johns Hopkins University Applied Physics Lab (JHU-APL).

Technical Description

By putting a spacecraft network in place in time for the next solar maximum, in about 2011, SDO will be able to investigate how the Sun's magnetic field is generated and how its energy is released into the space. Geospace Missions (GM) examines how solar variability changes Earth's ionosphere and radiation belts.

Theme: Earth-Sun System
Program: Living with a Star

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
SDO								Investigate the Sun's magnetic field.	Tech Form Dev Ops Res	Aug-02 Jul-04 May-08	Jul-04 Apr-08 Jul-13

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

Strategy For Major Planned Acquisitions

- Project management will be delegated from NASA Headquarters using the JHU-APL sole-source contract when GSFC is not the project implementer.
- SDO launch vehicle and SDO's HMI and EVE instrum. were selected through full and open competition. SDO's AIA instrum. was a sole source contract w/LM, & the spacecraft is an in-house build at GSFC.
- Geospace Missions Phase-A studies were selected through full and open competition.

Key Participants

- GSFC -- providing program management
- GSFC and JHU-APL -- providing project management

Risk Management

- RISK: Non-NASA organizations providing components late to LWS project causing schedule delays and cost increases. MITIGATION: Finalize inter-agency agreements that establish overall policy and commitments for each partnership.

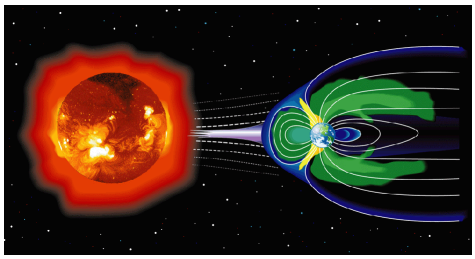
Theme: Earth-Sun System
Program: Solar Terrestrial Probes

President's FY 2006 Budget Request

(Dollars in Millions)

Solar Terrestrial Probes	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	157.5	100.3	78.8	94.8	140.8	125.1	128.4

Overview



Sun-Earth Connection

The primary goal of the Solar Terrestrial Probes (STP) Program is to understand how the Sun, heliosphere, and planetary environments are connected in a single system. To accomplish this overarching goal, STP missions will investigate the physics of the Sun from its interior through its atmosphere, the heliosphere from its inner region near the Sun to its outer reaches, Earth's magnetosphere and its interaction with the solar wind, and the ionosphere and upper atmospheres of Earth. These studies, which encompass the scientific disciplines of solar physics, heliospheric physics, magnetospheric physics, and aeronomy (the study of planetary upper atmospheres), will address questions such as the variability of the Sun, the coupling of the planets to these variations, and the interaction of the Sun and solar system. Each STP mission will respond to at least one of the following objectives: to understand the changing flow of energy and matter throughout the Sun, heliosphere, and planetary environments; to explore the fundamental physical processes of plasma systems in the universe; and to define the origins of solar variability and understand its role in driving space weather. Program supports the following annual performance goals 6ESS8 and 6ESS9.

For more information, please see:
http://stp.gsfc.nasa.gov/about.htm

Plans For FY 2006

Launch STEREO mission (February 2006).
Launch Solar-B mission (September 2006).
Begin Magnetospheric Multiscale (MMS) Phase-B (October 2005).

Changes From FY 2005

- STEREO project rebaseline resulting from cost increases due to spacecraft and instruments schedule slips (See STEREO project in Development section).

Program Management

Program management responsibility for the STP Program has been delegated to Goddard Space Flight Center.

Theme: Earth-Sun System
Program: Solar Terrestrial Probes

Technical Description

A Science Definition Team will define the technical performance required for each of the projects in the STP program. These requirements become the basis for Announcement of Opportunity for the acquisition of scientific instruments, and are ultimately documented in a project-unique Level 1 requirements document, which becomes an appendix to the program plan.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
STEREO								Understand the cause and consequences of coronal mass ejections.	Tech Form Dev Ops Res	 Nov-99 Mar-02 Mar-06 	 Feb-02 Feb-06 Mar-09
Solar-B								Measure the Sun's magnetic field and ultraviolet/x-ray radiation.	Tech Form Dev Ops Res	 Dec-98 Nov-00 Oct-06 	 Nov-00 Sep-06 Oct-10

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

Strategy For Major Planned Acquisitions

- NASA will use full and open competitions to the greatest extent possible for the acquisition of scientific instruments, spacecraft, and science investigations (including research & analysis).
- Certain instruments, missions or mission systems may be acquired without competitions (e.g., through international partnerships), provided there is a clear scientific or technological benefit to NASA.
- Missions may be implemented in the "out-of-house," or "PI mode," where the entire mission is acquired through full and open competition.

Key Participants

- Japan -- contributing spacecraft, launch vehicle, major elements of each scientific instrument, and operations for the Solar-B mission.
- Applied Physics Laboratory, Johns Hopkins University - providing two spacecraft and mission operations for STEREO mission.

Risk Management

- RISK: STEREO Observatory Schedule Erosion -- Continued schedule erosion would result in slip of Launch Readiness Date and increase in total cost. MITIGATION: Schedule rework to optimize parallel activities and work arounds. Closely monitor schedules.
- RISK: Solar-B Schedule Delay -- Japan may slip the Launch Readiness Date due to spacecraft technical issues. Would increase total cost. MITIGATION: Continue to negotiate schedule milestone with Japanese and monitor progress of schedules.

Theme: Earth-Sun System
Program: Explorer Program

President's FY 2006 Budget Request

(Dollars in Millions)

Explorer Program	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	128.7	103.6	117.1	106.8	137.3	208.6	197.2

Overview

The mission of the Explorer program is to provide frequent flight opportunities for world-class astrophysics and space physics investigations, utilizing innovative, streamlined and efficient management approaches to spacecraft development and operations. The Explorer program is composed of a long-term series of space science missions that are independent, but share a common funding and management structure. The program emphasizes missions that can be accomplished under the control of the scientific research community and seeks to control total mission life-cycle costs. The program also seeks to enhance public awareness of, and appreciation for, space science and to incorporate educational and public outreach activities. The Medium-Class Explorers (MIDEX) project provides flight opportunities for focused science missions. MIDEX investigations are characterized by the definition, development, launch service, and mission operations and data analysis costs set with each Announcement of Opportunity (AO). The Small Explorer (SMEX) project provides frequent flight opportunities for highly focused and relatively inexpensive missions. SMEX investigations are characterized by the definition, development, launch service, and mission operations and data analysis costs set within each AO. Mission of Opportunity (MO) space science investigations are flown as part of a non-NASA space mission. MOs are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission. This program supports all the ESS annual performance goals.

Explorers Patch

Link to the Explorers program homepage for information.
http://explorers.gsfc.nasa.gov/missions.html

Plans For FY 2006

Prepare The History of Events and Macroscale Interations during Substorms (THEMIS) for launch in October 2006.
Prepare Aeronomy of Ice in the Mesosphere (AIM) for launch in September 2006.
Prepare Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS)-B for launch in 3rd Quarter 2006.

Changes From FY 2005

- TWINS Launch delayed from the second quarter of 2004 and the second quarter of 2005 to the second quarter of 2005 and the second quarter of 2006.

Theme: Earth-Sun System
Program: Explorer Program

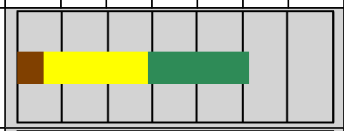
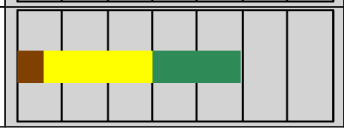
Program Management

The Explorer program is a multiple-project program with program responsibility assigned to GSFC.

Technical Description

The Explorer program will launch MIDEX and SMEX missions commensurate with the availability of funding. The launch of MOs are as appropriate, based on date selected, funding profiles, and expected launch dates for the host missions. The projects encourage a wide variety of methods for access to space. Expendible launch vehicles (ELVs), spacecraft from other programs, and long-duration balloons are all encouraged as ways to increase program flexibility and maximize flight opportunities for space science. ESS provides access to space and launch vehicle funding. These funds are part of the total cost cap for each mission. For each mission class, launch will take place within the following number of months after implementation: SMEX, 33 months; MIDEX, 40 months.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
THEMIS								Understand of the onset and evolution of magnetospheric substorms.	Tech Form Dev Ops Res	 Apr-02 Apr-04 Sep-06	 Apr-04 Aug-06 Oct-08
AIM								Determine the causes of Earth's highest-altitude clouds, which form in the coldest part of the atmosphere about 50 miles above the polar regions every summer.	Tech Form Dev Ops Res	 Jul-02 Apr-04 Oct-06	 Apr-04 Sep-06 Aug-08

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

Strategy For Major Planned Acquisitions

- Explorer program has established an acquisition strategy that contracts for whole mission (concept through delivery of science data/analysis), with emphasis on performance incentives.
- Investigations are selected through the AO process, where multiple investigations are selected for initial concept studies with a competitive down-select to proceed to the next stage of formulation.
- Investigations will be 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.

Key Participants

- Industry, academia, other government agencies, international partners.

Risk Management

- RISK: Implementation of first-of-a-kind space research missions are inherently risky. MITIGATION: Technical, management, and cost risks for each investigation are carefully examined as part of the selection process, and acceptable risks are documented in individual project appendices attached to the Explorer Program Plan. All technical and programmatic risks will be further reviewed as part of the project confirmation review during the PDR timeframe to ensure risks have been mitigated.

Theme: Earth-Sun System
Program: Earth System Science Pathfinder

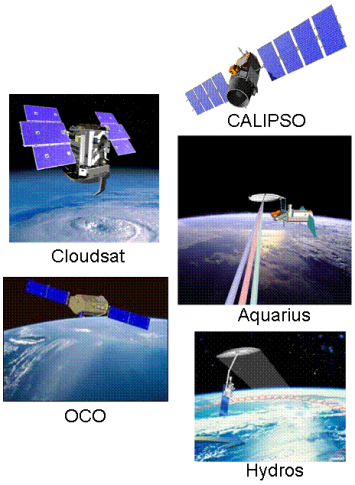
President's FY 2006 Budget Request

(Dollars in Millions)

Earth System Science Pathfinder	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	114.3	107.9	135.5	166.2	114.7	203.5	232.3

Overview

The Earth System Science Pathfinder program (ESSP) addresses unique, specific, highly-focused mission requirements in Earth science research. ESSP includes a series of relatively low to moderate cost, small to medium sized, competitively selected, principal investigator led missions that are built, tested, and launched in a short time interval. These missions are capable of supporting a variety of scientific objectives related to Earth science, involving the atmosphere, oceans, land surface, polar ice regions and solid earth. Investigations include development and operation of remote sensing instruments and the conduct of investigations utilizing data from these instruments. The ESSP program has two missions preparing for a co-manifested 2005 launch (CloudSat and CALIPSO), and 3 missions in formulation (Orbiting Carbon Observatory (OCO), Aquarius and, Hydros). Future ESSP missions will be selected from proposals submitted in response to AOs. These AOs will be released approximately once every 2 years, subject to funding availability. This effort also provides capabilities that can be employed to predict climate, weather, and natural hazards on planets we plan to explore. This program supports Objective 14 and Agency Performance Goals 6ESS25.



For more information see http://earth.nasa.gov/essp/.

Plans For FY 2006

If confirmed OCO will have completed pre-environmental integration and testing activities for the instrument and spacecraft. OCO will then hold a Pre-Environmental review for the instrument and spacecraft to assess readiness to conduct the appropriate electromagnetic interference, vibration, acoustic, and thermal/vacuum testing. If confirmed Aquarius will focus engineering efforts on the final design of the system, which will culminate in the Critical Design Review (CDR), the milestone review approval to proceed with hardware/software development. Two CDRs will be held: one for the NASA component of the system and one for the parts of the system under the responsibility of Argentine Comisión Nacional de Actividades Espaciales (CONAE). Hydros engineering efforts will be focused on the system definition phase of formulation. This effort includes development of the system concept and architecture, system specification, interface requirements, development test plans, risk analysis, and concept/design evaluation criteria. This will culminate in the Systems Requirements Review milestone review. AO-4 proposals will undergo ESSP peer-review evaluation and selection.

Changes From FY 2005

- CALIPSO and Cloudsat requirements replanned. Launch delay of 2 months to May 2005
- OCO and Aquarius schedule requirements rephased

Theme: Earth-Sun System
Program: Earth System Science Pathfinder

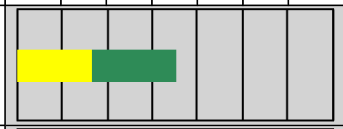
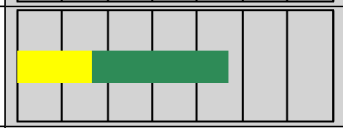
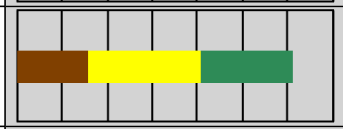
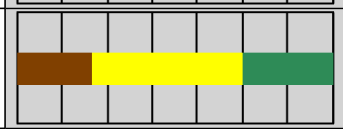
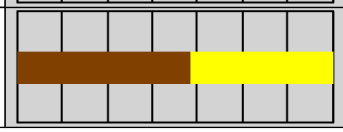
Program Management

PM: GSFC/LaRC-CALIPSO; JPL-CloudSat, OCO, Aquarius, and Hydros. The NASA and GSFC/JPL PM Councils have program oversight responsibility.

Technical Description

CloudSat: 1 instrument, mission life 22 months, measures cloud structure, ice & water content, improves knowledge of cloud processes. CALIPSO: 3 instruments, mission life 3 years, measures 3D distribution of aerosols in thin clouds. OCO: 1 instrument, mission life 2 years, first space-based measurement focused on atmospheric carbon dioxide to characterize its sources, sinks and seasonal variability. Aquarius: 2 instruments, mission life 3 years, global space-based measure of the sea surface salinity giving insight to the ocean's role in climate. Future ESSP including Hydros: 2 instruments, mission life 2 years, first satellite focused on earth's soil moisture and freeze-thaw state improving knowledge of terrestrial water cycle and its representation in weather and climate models.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Cloudsat								Improve cloud modeling and predictions of cloud formation and distribution.	Tech Form Dev Ops Res	 Sep-98 Oct-02 May-05	 Sep-02 May-05 Mar-07
Calipso								Address the role of clouds and aerosols in Earth's atmosphere.	Tech Form Dev Ops Res	 Jan-98 Jan-03 May-05	 Dec-02 May-05 May-08
OCO								Improve understanding of atmospheric carbon dioxide sources and sinks, a critical element in making more reliable climate predictions.	Tech Form Dev Ops Res	 Oct-03 May-05 Nov-07	 Apr-05 Oct-07 Nov-09
Aquarius								To observe and model seasonal and year-to-year variations of sea surface salinity and how these relate to changes in the water cycle and ocean circulation.	Tech Form Dev Ops Res	 Oct-03 Jun-05 Oct-08	 May-05 Sep-08 Oct-11
Hydros								Introduce improved cabability to predict costly natural hazards, such as extreme weather, floods, and droughts.	Tech Form Dev Ops Res	 Oct-03 Aug-07 Jan-11	 Jul-07 Dec-10 Jan-13

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

Strategy For Major Planned Acquisitions

- Hydros antenna: full and open competition
- AO-4 mission(s) selection: peer review

Key Participants

- International: CNES - provides CALIPSO spacecraft and satellite operations; CSA - provides CloudSat radar development, Hydros antenna feed assembly and radar data processing; CONAE - provides Aquarius spacecraft and ground system
- DoD - provides CloudSat satellite, mission operations, and Hydros launch vehicle
- DoE - provides CloudSat validation support

Risk Management

- RISK: CloudSat: If formation flying with CALIPSO and the insertion into the "A-Train" cannot be achieved, then optimum science results will not be achieved. There is a moderate likelihood that formation flying and insertion into the A-Train will not be achieved. MITIGATION: CloudSat: ESSP established the A-Train constellation working group, comprised of representatives from all satellite organizations and led by the GSFC Earth Science Mission Operations Office, to identify and resolve formation flying and A-Train insertion issues.

Theme: Earth-Sun System
Program: Earth-Sun System Multi-Mission Operations

President's FY 2006 Budget Request

(Dollars in Millions)

Earth-Sun System Multi-Mission Operations	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	414.9	334.3	268.3	269.5	277.1	280.4	285.7

Overview

Earth-Sun System Multi-Mission Operations acquires, preserves, and delivers the observation data for the Science Mission Directorate/Earth-Sun System scientific focus areas in conformance with national science objectives. Facilities involved in this undertaking include in-orbit spacecraft assets, spacecraft control centers, tracking and data-reception ground stations, related communications data handling systems, and data processing and archiving.

Multi-Mission Operations

The Ground Networks (GN) program is comprised of four parts: (1) the Orbital network for communications and navigation, (2) the research range that supports the NASA Sounding Rocket and Balloon programs, (3) the Merritt Island Launch Area and Ponce De Leon annex which provide Shuttle launch support communication and navigation information, and (4) cross-cutting effort that provides program management.

Science information systems receive raw observational data from the ground network and, with the help of science investigators, convert these observations into useful scientific information. NASA's principal Earth system information system is called "EOSDIS," or Earth Observing System Data and Information System. EOSDIS is the largest "e-science" system in the world. EOSDIS currently acquires, processes, archives, and distributes Earth science data and information products from over three terabytes of new satellite data per day. Having successfully created this system, NASA is now working to evolve it for the future, leveraging the continuing advance of information technology while providing continuous service to the user community.

This program supports Annual Performance Goals (APG) 14.3, 6ESS5 and 6ESS6

Plans For FY 2006

For 2006, the Multi-Mission Operations program will continue to provide safe and reliable spacecraft operation to ensure that science data collection meets the mission requirements for its science program customers. These requirements include meeting data quality needs, data latency, and temporal sampling requirements.

This program will engage in several activities targeting more efficient mission operations in the future. Multi-Mission Operations activities are under the Senior Review process.

The Senior Review is an integrated management process for extended missions (missions for satellites beyond their prime missions). In use previously for space science missions, the Senior Review has as its centerpiece an independent peer review to assign relative science merit of proposals submitted by science teams for extended missions. The first cycle for the Earth science mission Senior Review will award the competitively obtained funding for extended missions beginning in FY 2006. Senior Reviews will be conducted every two years.

NASA recognizes the necessity of modernizing its mission operations. The Directorate will begin preliminary planning for new strategies to meet future requirements and improve mission operations efficiency over the next decade.

Changes From FY 2005

- CloudSat/CALIPSO in operation (summer 2005).
- Include Earth Science missions in the Senior Review process.
- Establish an appropriate Ground Networks (GN) program funding level.

Program Management

The NASA, GSFC, and JPL Program Management Councils have program oversight responsibility.

Technical Description

Mission System Operations involves over 40 types of spacecraft, launch platforms and aircraft producing terabytes of data per day distributed to eight discipline data centers. Support is also provided for processing systems led by science investigators that provide processing of the data into geophysical parameters, such as atmospheric temperature and pressure, sea surface temperature, wind fields, and land surface conditions utilized by hundreds of NASA-funded researchers. This activity is accomplished continuously with high reliability and performance in pursuant of NASA's Earth, space, and human exploration objectives.

Theme: Earth-Sun System
Program: Earth-Sun System Multi-Mission Operations

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Multi-Mission Operations								Continued operation of spacecraft, launch platforms, and aircraft	Tech Form Dev Ops Res	Oct-03	Oct-10
EOSDIS								Acquisition, Process, archive, and distribution of Earth science data	Tech Form Dev Ops Res	Oct-03	Oct-10
Ground Network								Operation of ground network system	Tech Form Dev Ops Res	Oct-03	Oct-10
Alaska SAR Facility								Operation of Alaska SAR facility	Tech Form Dev Ops Res	Oct-03	Oct-10

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

Strategy For Major Planned Acquisitions

- The Senior Review process partly serves as a basis for Multi-Mission Operations acquisition decisions.

Key Participants

- International Space Agencies: Germany, France, and Japan. U.S. Agencies: National Oceanic and Atmospheric Administration, United States Geological Survey, and Department of Defense. Aerospace Industry: Raytheon, Honeywell and Northrop Grumman. Universities from the U.S. and abroad.

Risk Management

- RISK: The aging infrastructure of the Ground Networks system puts the missions in operations at risk. Changes in NASA's operating missions set over the next five years would require new strategies and planning to achieve necessary budget efficiencies and capabilities. MITIGATION: Begin preliminary strategy discussions covering revision of organizations, spacecraft control concepts and structures, and utilization of new technologies.

Theme: Earth-Sun System
Program: Earth-Sun Research

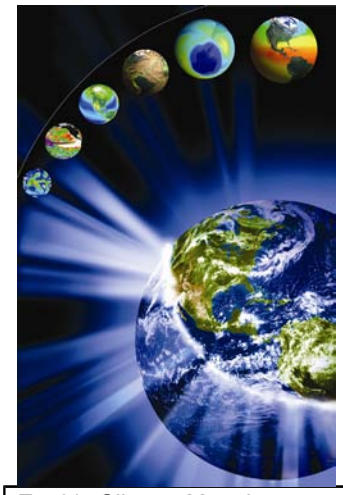
President's FY 2006 Budget Request

(Dollars in Millions)

Earth-Sun Research	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	927.4	818.6	845.1	815.7	811.8	798.8	802.5

Overview

The Earth-Sun System Division (ESSD) observations and research aim to improve our capability for predicting weather, climate and natural hazards, including space weather. The focus of NASA's efforts in ESSD is the development and demonstration of space-based measurements, providing information about the Earth-Sun system not available by other means. The use of this information increases knowledge of the system components and their interactions. The use of research results in complex models that generate improved environmental prediction is critical for policy and management decisions. NASA's program is an end-to-end one, beginning with the development of observational techniques and instrument technology, testing in the laboratory and/or from an appropriate set of suborbital (surface, balloon, aircraft, rocket) and/or space-based platforms; basic research and modeling. It is planned and implemented with national and international collaboration and coordination. ESSD research is a unique component of the U.S. Climate Change Science and Technology programs, the U.S. Weather Research program, the Earthscope program, and national research in the area of space weather.



Earth's Climate Mappings

This program supports Annual Performance Goals (APG) 14.4, 6ESS7

Theme: Earth-Sun System
Program: Earth-Sun Research

Plans For FY 2006

In order to plan and manage a scientifically effective program, the ESS research and analysis program is organized into seven interdisciplinary science focus areas. These focus areas form the basis for planning activities and program management and execution. The focus area roadmaps describe, at various levels of detail, plans for each area as well as joint activities planned to address cross-cutting aspects of the Earth System science. ESS research plans are a part of national plans and objectives for FY2006 as described in the Climate Change Science Program (CCSP) strategic plan (2002), and are reported by the program and the subcommittee on Global Change Research to Congress annually in the mandated report entitled "Our Changing Planet". The program will select and fund over 4,000 U.S. scientific research tasks through peer review. Research will utilize the fully implemented Earth Observing System to target high-priority questions of the Earth system, continue algorithm development and improvement, and conduct laboratory and field experiments to provide validation of the satellite-based observations. Computing capabilities are also funded through the high-end computing program to support modeling efforts and further program prediction goals.

In January 2005, the Science Mission Directorate will issue the Research Opportunities in Space and Earth Science 05 (ROSES-05), a research announcement covering all of the planned research solicitations in Earth-Sun System and Space Science for 2005. ROSES-05 describes the research goals in detail. The FY2006 budget will fund the proposed activities competitively selected.

Changes From FY 2005

- The ROSES-05 Omnibus NRA describes the new activity plans that will be initiated with FY 2006 program funds.

Program Management

NASA Headquarters has responsibility for the Earth-Sun System program.

Technical Description

The science focus area roadmaps describe plans for each area as well as the joint activities planned to address cross-cutting aspects of Earth-Sun science. The content of the Earth-Sun System Science Research program's new direction is defined in ROSES-05. However, the program elements that are not included in ROSES-05 may be solicited in future years.

ESSD is responsible for NASA's activities that address the combined, interacting system of Earth and the Sun to characterize their properties on a broad range of spatial and temporal scales, to understand the naturally-occurring and human-induced processes that drive them.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
The ROSES-05 schedule is as follows:								The purpose of the ROSES-05 is to solicit basic and applied research in support of the Science Mission Directorate.	Tech Form Dev Ops Res	Apr-05	Apr-08

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

Strategy For Major Planned Acquisitions

- The ESS research and analysis Program is based on full and open competition. Grants are peer reviewed and selected based on NRAs, and other relative announcements.

Key Participants

- A broad research community across the nation, specifically with NOAA, National Science Foundation (NSF), USGS, and other Federal and Foreign entities.

Theme: Earth-Sun System
Program: Applied Sciences

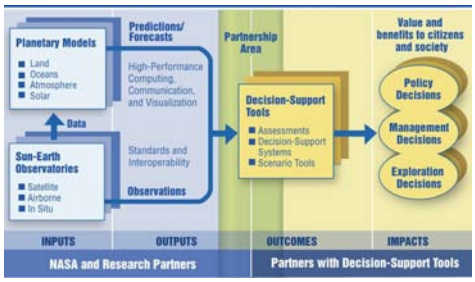
President's FY 2006 Budget Request

(Dollars in Millions)

Applied Sciences	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	30.3	43.5	52.2	51.5	50.8	48.9	54.3

Overview

The Applied Sciences program bridges the gap between scientific discoveries and practical applications that benefit society through partnerships that integrate the observations and predictions resulting from NASA Earth-Sun system science into solutions. Observations from NASA research spacecraft have proven to be valuable in improving forecasts of air quality conditions throughout the United States, assessing crop production estimates globally, and monitoring volcanic eruption activity to benefit aviation safety. Improved predictions and forecasts enabled by NASA science are systematically transitioned to serve national priority applications requiring environmental information on climate, weather, natural hazards, and sustainability. As we move forward into 2006, the NASA Applied Sciences program (DST) continues to benchmark contributions relevant to decision-support tools for policy, management, and exploration that are vital for the Nation's safety, security, and pioneering enterprises. This program supports Objective 14 and APG 6ESS20 and 6ESS21.



This diagram illustrates the assimilation of Earth-Sun system science observations and model products into decision support tools for policy, management and exploration.

For more information, please see http://science.hq.nasa.gov/earth-sun/applications/index.html.

Plans For FY 2006

The Applied Sciences Program will extend the results of research and development to increase understanding of the Earth-Sun system, and to support decisions for the exploration of Earth, the Moon, Mars and beyond. NASA, together with our partners, employs a systematic approach to benchmark the benefits of assimilating NASA research and development results into decision-support tools for areas of national priority: aviation, agriculture efficiency, public health, homeland security, ecological forecasting; and air quality, carbon, coastal, disaster, energy, invasive species and water management. A set of program element plans describes the projects and organizations working on the delivery of prototypes and benchmarks of integrated system solutions to contribute to these national priorities, addressing NASA goals and objectives. NASA collaborates with NOAA and other Federal agencies to systematically transition Earth-Sun system research results for operational utilization. NASA provides Earth and solar system scientists with verification of the performance of commercial remote sensing data products for use in exploration, thereby optimizing the value to the government of private sector investments in space. In FY 2006, the Develop activity will be expanded to develop human capital to meet future needs of the aerospace community. NASA will also participate in national and international organizations to establish standards and interoperability protocols and processes in support of national e-government programs.

Theme: Earth-Sun System
Program: Applied Sciences

Changes From FY 2005

- The Applied Sciences program was formerly the Earth Science Applications Theme.
- The Earth Science Applications Theme included Education and Outreach.
- The Applied Sciences program includes emphasis on extending the benefits of sun-solar system research as well as Earth system science research.

Program Management

Applied Sciences program responsibility is at NASA Headquarters, Office of the Earth-Sun Systems Division of the Science Mission Directorate.

Technical Description

The Applied Sciences Program is focused on working with Federal agencies and national organizations to optimize the use of technology and data associated with NASA's constellation of over 30 Earth-Sun system observing spacecraft. These spacecraft, which routinely make measurements using over 100 remote sensing research instruments, are used by a community of Earth-Sun scientists in laboratories, universities, and research institutions throughout the country, and around the world, to model the Earth-Sun system and improve predictions, projections, and forecasts.

Theme: Earth-Sun System
Program: Applied Sciences

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Agricultural Efficiency								Benchmark the assimilation of NASA observations (e.g., Jason, MODIS) and evaluate ESMF predictions into USDA CADRE DST.	Tech Form Dev Ops Res	Oct-05	Sep-06
Air Quality								Verify and validate Aura products and evaluate potential of NPP products to serve EPA and/or NOAA air quality DST (e.g., AIRNow, CMAQ, WRF).	Tech Form Dev Ops Res	Oct-05	Sep-06
Aviation								Benchmark ESMF predictions in FAA DSTs (e.g., oceanic weather). Evaluate the potential of NPP observations to serve the FAA National Airspace System DST.	Tech Form Dev Ops Res	Oct-05	Sep-06
Carbon Management								Benchmark the assimilation of NASA observations (e.g., Terra, Aqua) in CASA/CQUEST DST. Evaluate or verify potential of carbon sequestration forecasts into USDA DST.	Tech Form Dev Ops Res	Oct-05	Sep-06
Coastal Management								Benchmark Aqua observations and model ocean condition products into NOAA HAB forecast. Evaluate potential of NPP products to serve coastal DST (e.g., GNOME).	Tech Form Dev Ops Res		
Disaster Management								Evaluate, verify and validate the potential of NPP sensor data (e.g., AIRS, CRIS, VIRS) into NOAA AWIPS DST	Tech Form Dev Ops Res	Oct-05	Sep-06
Ecological Forecasting								Benchmark assimilation of NASA observations (e.g., Terra, Aqua) and evaluate capacity of NPP observations and ESMF predictions to serve CCAD SERVIR DST	Tech Form Dev Ops Res	Oct-05	Sep-06
Energy Management								Evaluate capacity to assimilate NASA observations(eg CERES, SOHO, NPP) & ESMF predictions to energy DST's(DOE/NEMS, EPRI). Benchmark assimilation of products in DST (RETScreen,HOMER,NSRDB).	Tech Form Dev Ops Res	Oct-05	Sep-06
Homeland Security								Benchmark the assimilation of 2 or more ESMF predicitions into DHS Interagency Modeling and Atmospheric Assessment Center (IMAAC)	Tech Form Dev Ops Res		
Invasive Species								Verify and validate the capacity of NASA observations & ESMF predictions to serve USGS DST's.	Tech Form Dev Ops Res	Oct-05	Sep-06
Public Health								Verify and validate the capacity of NASA Earth-Sun System research results to serve NIH DST.	Tech Form Dev Ops Res		
Water Management								Verify, validate, and benchmark the assimilation of NASA observations (e.g., MODIS) and Land Information System products into DoI Bureau of Reclamations Riverware/AWARDS DST.	Tech Form Dev Ops Res	Oct-05	Sep-06

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

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Crosscutting Solutions								Research to Operations: Implement approach for transition of NASA Earth-Sun system research data products for use by NOAA.	Tech Form Dev Ops Res	Oct-05	Sep-06
Crosscutting Solutions (Continued)								IWGEO: Deliver at least 5 benchmark reports for integrated system solutions	Tech Form Dev Ops Res	Oct-05	Sep-06
Crosscutting Solutions (Continued)								CCSP: deliver synthesis and assessment report (5.1) on uses and limitations of climate change measuremets and forecasts for decision support.	Tech Form Dev Ops Res		
Crosscutting Solutions (Continued)								Demonstrate interoperability on the use of research measurements, models, and solution in an Earth-Sun System Gateway (ESG).	Tech Form Dev Ops Res		

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

Strategy For Major Planned Acquisitions

- Not Applicable

Key Participants

- Committee on Environment and Natural Resources, Committee on Climate Change Science and Technology Integration, Interagency Working Group on Earth Observations and bilateral agreements with Federal agencies and national organizations: Benchmark integrated system solutions.
- NOAA and other Federal agencies: Systematically transition Earth-Sun system research results for operational utilization.
- Joint Agency Commercial Imagery Evaluation (JACIE): Provide Earth and solar system scientists for verification of performance of commercial remote sensing data products for exploration.

Theme: Earth-Sun System
Program: Education and Outreach

President's FY 2006 Budget Request

(Dollars in Millions)

Education and Outreach	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	23.8	22.9	23.3	23.4	23.8	25.4	27.6

Overview

The Earth-Sun System Education and Outreach program uses NASA's results from studying the Earth system and the Sun to enhance the teaching and learning of Earth, space, and environmental sciences through partnerships with educational institutions and organizations. In coordination with the NASA Office of Education, the program makes the discoveries and knowledge generated from Earth-Sun system studies accessible to students, teachers, and the public by enabling dynamic and engaging learning environments.

ESS Education Outreach

In addition to developing curriculum and exhibit support materials, the program places particular emphasis on teacher preparation and professional development for educators in both formal and informal education. Please see exemplary projects described in the Earth Science Education and Outreach Plans referenced below.

The program communicates through public events why and how NASA develops new space-based capabilities for the purpose of understanding and protecting Earth. The NASA Earth Observatory is also an exemplary resource, featuring stories, imagery, and data for the public and professionals who are not necessarily experts in Earth and environmental science.

The program also ensures the continued training of interdisciplinary scientists to support the study of the Earth-Sun system through graduate fellowships and early career awards.

This program support Objective 13 and Outcomes 13.1, 13.2 and 13.5.

For more information, please see
http://science.hq.nasa.gov/strategy/index.html
http://earthobservatory.nasa.gov/

Plans For FY 2006

Support projects competitively selected in FY 2005 that will increase K-12 educator support for teaching Earth science and geography, strengthen undergraduate institutional capacity in Earth system science and applications (with particular emphasis on 2 and 4-year colleges and minority-serving institutions), and enhance public scientific literacy about the Earth system and the environment.

Continue the GLOBE program worldwide implementation and U.S. coordination of educational partnerships, in collaboration with the National Science Foundation.

Support continued development of a competent technical workforce, including approximately 150 graduate fellowships pursuing masters and/or Ph.D. degrees and 30 early-career awards for Ph.D. scientists and engineers in Earth-Sun system studies.

Provide in public venues at least 50 stories on the scientific discoveries, practical benefits, or new technologies sponsored by the Earth-Sun System Division, and present at least five exhibits with a total of at least 50,000 attendees. Continue to publish exciting NASA Earth science imagery and provide explanations of the phenomena through the Earth Observatory and other NASA Web sites.

Changes From FY 2005

- None

Program Management

The HQ program office in the Earth-Sun System Division, Science Mission Directorate, is responsible for the Earth-Sun Education and Outreach program.

Technical Description

Not applicable.

Strategy For Major Planned Acquisitions

- The acquisition strategy is primarily peer review, competitive sourcing, and/or Space Act agreements. Non-NASA performer acquisitions are primarily grants or cooperative agreements.

Key Participants

- Performing organizations include academic and/or educational institutions (e.g., colleges, universities, museums, science centers, etc.), research and/or non-profit organizations, and state and local governments, (e.g., Boston Museum of Science, Houston Museum of Natural Science).

Risk Management

- RISK: None MITIGATION: None

Theme: Earth-Sun System
Program: Earth-Sun Technology

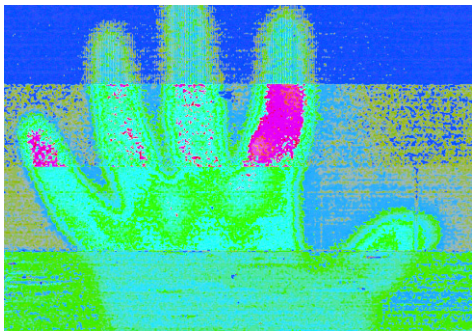
President's FY 2006 Budget Request

(Dollars in Millions)

Earth-Sun Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	207.0	121.8	127.4	146.6	151.8	135.6	139.3

Overview

NASA's ESSD is dedicated to understanding the total Earth-Sun system and the effects of natural and human-induced changes on the global environment. Advanced technology will play a major role in enabling the Earth-Sun research and applications programs of the future. The Earth Sun Technology program (ESTP) enables Earth-Sun science and application programs by providing new capabilities and reducing the cost of Earth science measurements planned in the near, mid, and far term. ESTP also ensures consistency between the Earth-Sun science plan and the implementing technology strategy as manifest in the Earth-Sun Technology program and other relevant Agency programs.



Detector developments enable new imaging techniques that will improve scientific remote sensing, industrial monitoring, and medical diagnosis.

The Earth-Sun System Technology Office (ESTO) provides strategic, science-driven technology assessments, and requirements development. It implements the science focused technology program by pursuing promising scientific and engineering concepts and ensuring that the program maintains an effective balance of instrument and information systems investments.

The New Millennium program (NMP) is designed to retire risk of key emerging and breakthrough technologies to enable future missions through flight validation.

This program supports Objective 14 and APG 6ESS4.

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

Plans For FY 2006

The ESTP will plan and implement development of new remote sensing and information systems technologies for infusion into future Earth-Sun system missions that will enable, or dramatically enhance, measurements and data system capabilities.

Planning starts with measurement priorities established by the science community that leads to systematically developed technology requirements and priorities that are captured in a Web-accessible database. Technology roadmaps are developed and fed into the Agency-level capability roadmaps. Studies are conducted to assess measurement options into technology performance requirements.

Implementation is performed through open competition solicitations in three elements. Instrument Incubator program develops new and innovative instruments and measurement techniques at the system level including laboratory development and airborne validation. An NRA will be issued. Advanced Information Systems Technology develops end-to-end information technologies that enable new Earth observation measurements and information products. Selections for an NRA are planned for early FY 2006. Advanced Technology Initiatives implements a broad array of technology developments for state-of-the-art components for instruments and earth and space-based platforms. Requirements are also developed for Advanced Platform Technology. An Integrated Technology Development Plan is updated annually.

NMP projects are designated as Space Technology projects, being either system development/validation or subsystem development/validation. Advances in technology development are documented annually.

Changes From FY 2005

- The basic program content has not changed from the FY 2005 budget submit.

Program Management

The ESTO program office is located at GSFC. HQ ESSD has program oversight responsibility. NMP is managed at JPL.

Technical Description

Instrument Incubator project: Instrument technology investments include passive and active sensing techniques, such as radar systems, large lightweight antennas, and active optical sensors using lasers.

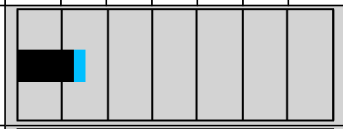
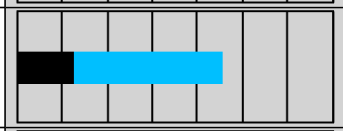
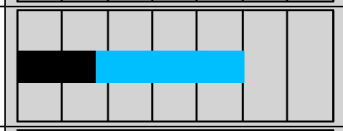
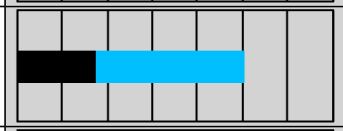
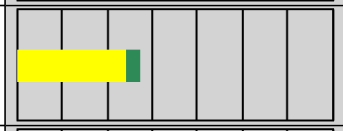
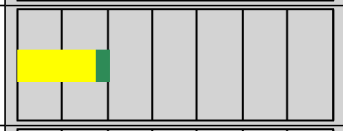
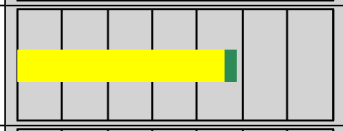
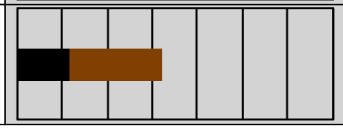
Advanced Information Systems Technology: Technology developments include on-board processing, space communications, mission automation for self-tending spacecraft and instruments, and information synthesis to derive information from extremely large, complex data sets.

Advanced Technology Initiative: Concept studies and component and subsystem technologies serving as the building blocks for instruments, platforms, and information systems.

NMP: Primary path to flight-validate key emerging technologies to retire risk and reduce cost of future science missions.

Theme: Earth-Sun System
Program: Earth-Sun Technology

Implementation Schedule:

Project	Schedule by Fiscal Year	Purpose	Phase Dates		
	04 05 06 07 08 09 10			Beg	End
Integrated Technology Development Plan		Annual plan provides prioritized technology goals and the plan for achieving them	Tech Form Dev Ops Res	Jan-05	Mar-05
Instrument Incubator Program NRA		NRA to develop remote sensing instruments to a level that mission developers would consider infusing	Tech Form Dev Ops Res	Jan-05	Mar-08
Advanced Info Systems Technology NRA		NRA to develop information systems technologies for spacecraft and terrestrial uses	Tech Form Dev Ops Res	Jul-05	Sep-08
Advanced Technology Initiatives NRA		NRA to develop component and subsystem technologies	Tech Form Dev Ops Res	Jul-05	Sep-08
Space Technology (ST)-5		Integrated system validation of a constellation of multiple nanosat spacecraft	Tech Form Dev Ops Res	 Jan-99 Nov-01 Mar-06	 Nov-01 Feb-06 Jun-06
ST-6		Subsystem validation of autonomous spacecraft experiment and inertial stellar compass	Tech Form Dev Ops Res	 Sep-00 Aug-02 Jul-05	 Aug-02 Jun-05 Oct-05
ST-7		System technology flight validation mission of disturbance reduction system	Tech Form Dev Ops Res	 Dec-00 Jul-03 May-08	 Jul-03 May-08 Aug-08
ST-8		Approval for Implementation -- ST-8 is a subsystem technology validation project	Tech Form Dev Ops Res	 Nov-03	 Jul-05
ST-9		Proposals still in evaluation for Phase-A studies	Tech Form Dev Ops Res	 Dec-04	 Dec-06

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

Strategy For Major Planned Acquisitions

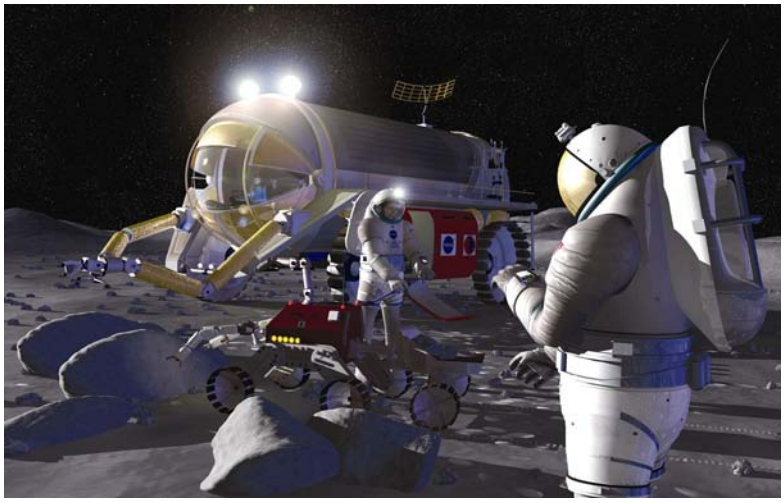
- Tasks are procured primarily through full and open competition.
- Tasks are procured for the following programs: Instrument Incubator Program, Advanced Information Systems Technology, Advanced Technology Initiatives and Technology validation concepts.

Key Participants

- NRA task awardees include industry, academia, non-profit, other government agencies, and NASA intramural.
- Other technology programs are leveraged through partnerships with Small Business Innovative Research, the Exploration Systems Research and Technology program, NASA Institute of Advanced Concepts, and other Federal agencies.

Risk Management

- RISK: Selected technologies may fail to mature, or utilitately be utilized in a future NASA mission/application. Likelihood: possible. Selecting only those technologies that are certain to mature and be infused precludes the pursuit of promising and needed technologies that are innovative but risky. MITIGATION: ESS will pursue a portfolio of technologies that balance innovation and risk with requirements that are clearly traceable to the strategic objectives of the Earth-Sun System Theme.



An artist's concept of a future lunar exploration mission.

Themes

Constellation Systems

Exploration Systems Research and Technology

Prometheus Nuclear Systems and Technology

Human Systems Research and Technology

EXPLORATION SYSTEMS

Purpose

The role of the Exploration Systems Mission Directorate (ESMD) is to develop a constellation of new capabilities, supporting technologies, and foundational research that enables sustained and affordable human and robotic exploration. The research and technology development activities of the former Exploration Systems Enterprise and former Biological and Physical Research Enterprise have been merged and are now both managed in ESMD. Organized in this way, ESMD will be able to fully integrate the critical human system element with the broad engineering systems infrastructure required for the human exploration of the Solar System. This full integration enables the early insertion of critical human support requirements to implement safety, sustainability, and exploration crew effectiveness.

Within ESMD the development of exploration strategies, systems, and technologies is guided by four overarching principles:

Corporate Focus: ESMD works in partnership with all NASA Directorates integrating complex work from multiple organizations in order to best achieve the Vision. To that end, decisions in ESMD are made using a simple benchmark: To what degree does each decision advance NASA's overarching goals?

Focused, Prioritized Requirements: The Directorate involves users, operators, researchers, and technologists to craft focused, prioritized requirements for new capabilities. These requirements will be based on realistic parameters for cost, schedule, and performance. ESMD does and will continue to use sound risk reduction methods to promote safety and mission success, and will not allow for "requirements creep." Once established, requirements will be rigorously controlled.

Mission Directorate: Exploration Systems

Spiral Transformation: A key challenge for the Directorate is to develop new capabilities in a manner that is pragmatic – so that new capabilities can be developed and used to advance exploration in the near term – while also being flexible, in order to incorporate new technologies and respond with agility to scientific discoveries. To meet this challenge, the Directorate will develop exploration capabilities in stages, or "spirals." Each spiral will usher in a set of major new capabilities in support of the Vision. Spirals will be structured based on specific requirements, well-defined goals and endpoints, then-current technologies, manageable risks, an executable budget, and knowledge gained from prior in-space activities.

Management Rigor: The Directorate is engaged in a disciplined management approach. ESMD establishes time-phase priorities, applies risk-management principles, ensures performance within budget, and nurtures personnel development to ensure that programs and projects achieve NASA's goals in an affordable and sustainable way. This management approach is supported by a sound acquisition strategy that promotes success and innovation.

The Exploration Systems Mission Directorate consists of four Themes that will function cooperatively to enable exploration and scientific discovery. Those Themes are Exploration Systems Research and Technology, Human System Research and Technology, Constellation Systems, and Prometheus Nuclear Systems and Technology.

FY 2004 Accomplishments

- Transformed and merged the Exploration Systems Enterprise and the Biological and Physical Research Enterprise to form the Exploration Systems Mission Directorate.
- Contracted with 11 Concept Exploration and Refinement teams from industry and academia to develop architectural solutions for lunar exploration and concepts for the Crew Exploration Vehicle.
- Formulated new Exploration Systems Research and Technology programs to support the Vision, and competitively selected 48 peer reviewed intramural technology development projects performed by NASA Centers and 70 peer reviewed extramural technology development projects via a Broad Agency Announcement.
- The former Biological and Physical Research Enterprise has been transformed into the Human System Research and Technology Theme. The focus of the research and development effort has shifted from a discipline focus to a requirements-driven product-delivery focus. A zero-based program review was initiated in to identify gaps in research required to support ESMD and Vision.
- Signed Memorandum of Understanding between NASA and Department of Energy Office of Nuclear Reactors for development of an in-space nuclear reactor.

Theme Distribution

Budget Authority ($ in millions)	FY 2004	FY 2005	FY 2006
Constellation Systems*	911.5	526.0	1120.1
Exploration Systems Research and Technology*	676.7	722.8	919.2
Prometheus Nuclear Systems and Technology+	220.7	431.7	319.6
Human System Research and Technology**	985.6	1003.9	806.4
Total	2,794.5	2,684.5	3,165.4

Note: For all formats, the FY 2004 column reflects the FY 2004 Congressional Operating Plan, dated 9/28/2004. The FY 2005 column reflects the FY 2005 Congressional Operating Plan, dated 12/23/2004. The FY 2006 column represents the FY 2006 President's Budget Submit.

*In the FY 2005 Exploration Systems Enterprise, the Exploration Systems Research and Technology Theme and the Constellation Systems Theme were the Human and Robotic Technology and Transportation Systems Themes, respectively.

**The Human System Research and Technology Theme in FY 2005 was the Biological and Physical Research Enterprise. Some projects have been transferred from this Enterprise to the Exploration Systems Research and Technology Theme.

+In FY 2005 Prometheus Nuclear Systems and Technology was a program within the Human and Robotic Technology Theme.

Constellation Systems

Through the Constellation Systems Theme NASA will develop, demonstrate, and deploy the collection of systems that will enable sustained human and robotic exploration of the Moon, Mars, and beyond. These include the Crew Exploration Vehicle (CEV) for the transport and support of human crews traveling to destinations beyond low Earth orbit, as well as launch vehicles for transport of the CEV and cargo to low Earth orbit, and any ground or in-space support infrastructure for communications and operations. These systems, collectively known as the "System of Systems" will be developed in a "spiral" approach, wherein early demonstrations and prototypes are used to demonstrate capabilities, validate technologies, and mitigate risk, all along an evolutionary path toward a mature design. The first spiral development planned for Constellation Systems will provide the capability to deliver humans to orbit in a CEV by 2014. The second spiral will deliver humans to the lunar surface by 2020, followed by the third spiral that will enable extended visits on the lunar surface. As spiral development evolves, System of Systems elements will grow to include in-space support systems, destination surface systems, and additional human support systems.

Overall Budget

The FY 2006 request is $1,120.0 million; a $594.1 million (or 113 percent) increase from the FY 2005 budget. Major features of this budget include:

- Funding to support the initial development activities for the CEV. ESMD will be engaged in a competitive process awarding at least two contracts for the development of the CEV by 2014 and a related risk reduction demonstration mission in 2008. This risk reduction effort will lead the CEV project to select one contractor in 2008 to build the CEV for Spiral 1.
- Funding to support the establishment of a lead Systems Engineering and Integration capability for Constellation Systems. This funding will support a systems integration team (probably led by a combination of a NASA Center and industry contractor) to ensure efficient and effective integration of all aspects of the Earth Orbit Capability program – the CEV, the Crew Launch Vehicle, and all associate ground and in-space support systems.

EARTH ORBIT CAPABILITY

The Earth Orbit Capability (Spiral 1) program is responsible for developing, demonstrating, and deploying the capability for crew transportation to Earth orbit. The budget request includes funding to continue the development of those systems critical to achieve the goals of the Vision for Space Exploration. Specifically, these systems include the CEV, Crew Launch Vehicle, and supporting ground and in-space systems. Earth Orbit Capability is the first spiral in a well-defined spiral development process. Spiral 1 will demonstrate crew transportation capability to Earth orbit by 2014 and will verify crew CEV and Crew Launch Vehicle readiness to support the Spiral 2 mission to the Moon. The following Spiral 2 program will develop, demonstrate, and deploy the additional capability to support human missions to the lunar surface no later than 2020.

Exploration Systems Research and Technology

The Exploration Systems Research and Technology (ESR&T) Theme represents NASA's commitment to investing in the technologies and capabilities that will make the national vision for space exploration possible. The goals of solar system exploration, not just for ESMD, but for all of NASA, will be the primary focus of Theme activities and will demand a robust, ongoing commitment to focused innovation. Through such a focused research and development effort the Theme will develop technologies that can be timely integrated into different spirals and different missions. The ESR&T theme is working closely with other government agencies, industry, academia and other partners to leverage common requirements and identify innovative ideas.

Overall Budget

The FY 2006 request is $919.2 million, a $196.4 million (or 27 percent) increase from the FY 2005 budget. Major features of this budget include:

- Funding for the Advanced Space Technology and Technology Maturation programs to continue competitively awarded technology development contracts to NASA Centers, industry, and academia.
- A newly restructured Technology Transfer Partnerships project to improve NASA's ability to both spin-out and spin-in new technologies.
- Increased funding for the Centennial Challenges program.

ADVANCED SPACE TECHNOLOGY

The Advanced Space Technology program develops new technologies that will enable NASA to conduct new human and robotic exploration missions, gather new types of scientific data, and reduce mission risk and cost. The request includes funding for the advanced system concepts, fundamental technologies, and engineering tools that the Advanced Space Technology program are developing unique to NASA needs, and applicable across many classes of missions. Accordingly, the research activities in the Advanced Space Technology program are organized into five major technical areas that are fundamentally critical to all NASA missions: Advanced Studies, Concepts, and Tools; Advanced Materials and Structural Concepts; Computing, Communications, Electronics, and Imaging; Power, Propulsion, and Chemical Systems; and Software, Intelligent Systems, and Modeling.

TECHNOLOGY MATURATION

The Technology Maturation program develops and validates the most promising advanced space technology concepts and matures them to the level of demonstration and space flight validation, to enable safe, affordable, effective and sustainable human-robotic exploration. The request includes funding to support the goals of the Technology Maturation program, specifically, identifying technologies that are emerging from NASA's Advanced Space Technology program, and other NASA and non-NASA advanced technology programs, and maturing them from moderate readiness to high levels of readiness for transition to Constellation Systems and other applications.

INNOVATIVE PARTNERSHIPS

The request includes funding to help the Innovative Partnerships program provide technological solutions for meeting solar system exploration and other NASA needs through novel partnerships with the aerospace industrial firms, the venture capital community, small businesses, and universities. The Innovative Partnerships program consists of NASA's Technology Transfer efforts, the Small Business Innovation Research and Small Business Technology Transfer programs, and other means for unique partnerships outside of NASA, such as the University Research and Engineering Technology Institutes.

CENTENNIAL CHALLENGES

The request includes funding to continue the evolution of the Centennial Challenges program. The Centennial Challenges program conducts prize competitions for revolutionary, breakthrough accomplishments that advance solar system exploration and other NASA priorities. Some of NASA's most difficult technical challenges may require novel solutions from non-traditional sources of innovation. By making awards based on actual achievements instead of proposals, NASA hopes to tap innovators in academia, industry, and the public that do not normally work on NASA issues.

Prometheus Nuclear Systems and Technology

Prometheus Nuclear Systems and Technology was formerly a program within the Human and Robotic Technology Theme of the Exploration Systems Enterprise. With NASA's organizational transformation the unique and exciting efforts of Prometheus Nuclear Systems and Technology have been organized into their own Theme.

Prometheus Nuclear Systems and Technology represents NASA's effort to develop an advanced technology capability for more complex operations and exploration of the solar system. Historically, space exploration has been limited by the power available from solar and other non-nuclear sources. Radioisotope power systems, a passive form of nuclear power, have enabled a wide range of outer planetary exploration missions over the past 40 years, as evidenced by the Galileo and Cassini spacecraft. The development of more sophisticated, more capable (i.e., heavier) spacecraft, or the potential need for more robust power systems on the surface of the Moon or Mars, may require the development of the more powerful and efficient capability provided by nuclear fission. In cooperation with the Department of Energy, NASA's current research and development effort is focused on the first demonstration of a space-based nuclear reactor.

Overall Budget

The FY 2006 request is $319.6 million, a $112.1 million (or 26 percent) decrease from the FY 2005 budget. An investigation of Jupiter's icy moons will not be the first demonstration for Prometheus Nuclear Systems and Technology, as concerns over costs and technical complexity prompted NASA to defer the Jupiter Icy Moons Orbiter mission. NASA is now conducting an Analysis of Alternatives to identify a mission relevant to exploration and scientific goals, with reduced technical, schedule, and operational risk.

ADVANCED SYSTEMS AND TECHNOLOGY

The request includes funding to continue work in the Advanced Systems and Technology program to develop and demonstrate advanced nuclear technologies and engineered systems. This technology development will be necessary to support NASA's goal of more distant, more ambitious, and longer duration human and robotic exploration of Mars and other destinations. Specifically, this program will conduct advanced research and development for follow-on and second-generation advanced missions and applications.

NUCLEAR FLIGHT SYSTEMS

The request includes funding for the Nuclear Flight Systems program to continue development of nuclear reactor power and associated spacecraft systems to enhance NASA's abilities to conduct robotic exploration and science operations. The Nuclear Flight System program maintains two interrelated activities in the development of its products. First, through the Department of Energy Office of Naval Reactors, the program sponsors the full spectrum of nuclear technology and engineering development activities to develop a space qualified nuclear power reactor. Concurrently, NASA is developing spacecraft structures, systems, and components that are suitable for integration with a high-power space nuclear reactor system.

Human Systems Research and Technology

The Human Systems Research and Technology (HSR&T) Theme is new to ESMD and is comprised of several of the efforts of the former Biological and Physical Research Enterprise (BPRE). The programs of BPRE have been transformed from a discipline focus on biological and physical research, to a requirements-driven product-delivery focus. A zero-based program review is underway to identify any gaps in research required to support ESMD and the Vision. The Theme now focuses on ensuring the health, safety, and security of humans through the course of solar system exploration. Programs within this Theme advance knowledge and technology critical for

supporting long-term human survival and performance during operations beyond low-Earth orbit, with a focus on improving medical care and human health maintenance. Within the Theme there are three programs: Life Support and Habitation; Human Health and Performance; and Human Systems Integration. The Life Support and Habitation program conducts research and develops technology for life support and other critical systems for spacecraft operations. The Human Health and Performance program delivers research on questions about human biology and physiology relevant to the human exploration of the solar system, and delivers technology to help maintain or improve human health in the space environment. The Human Systems Integration program focuses on optimizing human-machine interaction in the operation of spacecraft systems.

Overall Budget

The FY 2006 request is $806.4 million, a $197.5 million (or 20 percent) decrease from the FY 2005 budget. By transforming the BPRE organization and adopting a requirements-based philosophy in the redirection of its programs NASA will be able to reprioritize ISS research and realize efficiencies in its investments by focusing them on technologies applicable to human exploration of the solar system. Such efficiencies allow NASA to adjust the investment profile for HSR&T and still return significant benefits to the space program.

LIFE SUPPORT AND HABITATION

The request includes funding for the Life Support and Habitation program to focus on enabling human exploration beyond low Earth orbit by developing technologies to support human activity in and beyond low Earth orbit. Some of the technologies to be developed by the Life Support and Habitation program include closing the loop for air, water, and food to make exploration missions feasible and to reduce mission logistics and cost; achieving a new level of reliable and maintainable life support and environmental monitoring and control systems; and developing novel technologies to enhance exploration crew autonomy.

HUMAN HEALTH AND PERFORMANCE

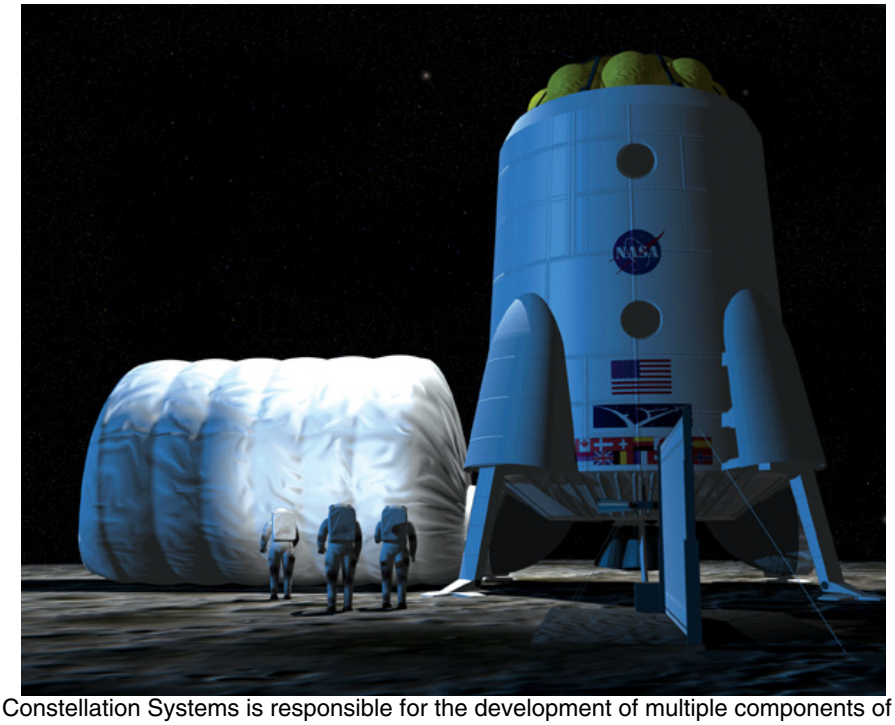
The request includes funding to support the Human Health and Performance program deliver research, technology, knowledge, and tools that will enable human space exploration. Specifically, the Human Health and Performance program will guide the development of various countermeasures to aid astronauts counteract any deleterious effects of long-duration missions in the space environment; develop tools and techniques to improve medical care delivery to space exploration crews; increase our biomedical knowledge and improve understanding of radiation effects to reduce the uncertainty in estimating space radiation health risks to human crews; and, acquire new information in exploration biology, which will identify and define the scope of problems that will face future human space explorers during long periods of exposure to space.

HUMAN SYSTEMS INTEGRATION

The request includes funding for the Human-Systems Integration program to conduct research and technology development driven by Agency needs for crew health; design of human spacecraft, space suits, and habitats; efficient crew operations; medical operations; and technology development to enable safe and productive human space exploration. The program addresses identified needs in physical and cognitive performance factors, psychosocial adaptation, neurobehavioral adaptation, and sleep and circadian rhythms. This research is important because the human system has physical and cognitive interface requirements that must be addressed in spacecraft design and operation. This research will inform the development of engineering standards, guidelines, requirements, design tools, training systems and evaluation approaches to support astronauts, design engineers and missions operations.

Theme: Constellation Systems

Constellation System s



Constellation Systems is responsible for the development of multiple components of an overall exploration architecture, like this future future lunar surface system.

President's FY 2006 Budget Request

(Dollars in Millions)

Constellation Systems	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	911.4	526.0	1,120.1	1,579.5	1,523.7	1,990.9	2,452.2
Changes from FY 2005 Request	-55.1	-162.7	-140.9	-44.4	100.8	127.9	

Overview: *What* NASA Accomplishes through the Constellation Systems Theme

The Constellation Systems Theme is responsible for developing, demonstrating, and deploying successive generations of new capabilities to enable sustainable and affordable human and robotic exploration of the Moon, Mars, and beyond. Capabilities will be developed within well-defined program spirals. The initial program spiral delivers a human Earth Orbit Capability by 2014. This includes a risk reduction demonstration in 2008 and flight tests in 2011 without crew. Following program spirals will deliver the capability to support human missions to the lunar surface no later than 2020 and then to Mars. Specifically, future Spirals are defined as follows: Spiral 2 is a Lunar Landing Capability; Spiral 3 is an Extended Lunar Stay Capability; Spiral 4 is a Mars Landing Capability, with further spirals still to be defined.

The capabilities that will support these spirals form a System of Systems that include crew transportation systems, cargo transportation systems, in-space support systems, destination (Moon, Mars) surface systems, Earth ground systems, and human support systems. The Earth Orbit Capability (Spiral 1) Program within the Constellation Theme will manage the Crew Exploration Vehicle (CEV), the Crew Launch Vehicle (CLV), and supporting ground and in-space support systems projects.

Theme: Constellation Systems

Relevance: *Why* NASA conducts Constellation Systems work

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

The Constellation Systems Theme is responsible for developing capabilities essential to making the Vision for Space Exploration a reality. To deliver these capabilities, the Constellation Systems Theme will:

-Develop a Crew Exploration Vehicle to provide crew transportation for missions beyond low Earth orbit with an initial flight test no later than 2014;

-Undertake human lunar exploration to support sustained human and robotic exploration of Mars and beyond;

-Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than 2020;

-Enable human exploration of Mars.

Relevance to the NASA mission:

The Constellation Systems Theme supports NASA's mission to explore the universe and search for life by developing the transportation and supporting capabilities to extend human presence to the Moon, Mars, and beyond. A human presence will enable scientific activities and discoveries otherwise unattainable with only robotic explorers.

Relevance to education and public benefits:

Constellation Systems will help create a more secure world and improve quality of life by investing in the aerospace industry and academia, and the programs of Constellation Systems will involve the public and educators to inspire students to enter the science, mathematical, and engineering fields.

Performance

Major Activities Planned for FY 2006:

- System Requirements Review of the Earth Orbit Capability (Spiral 1) program and approval to begin the Concept Development and Preliminary Design phase of the Earth Orbit Capability (Spiral 1) program.

Major Recent Accomplishments:

- Contracted with 11 Concept Exploration and Refinement teams from industry and academia to develop innovative architectural solutions for lunar exploration and concepts for the CEV.

Theme: Constellation Systems

Constellation Systems Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

7. Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit. First test flight to be by the end of this decade, with operational capability for human exploration no later than 2014.

7.1 By 2014, develop and flight-demonstrate a human exploration vehicle that supports safe, affordable and effective transportation and life support for human crews traveling from the Earth to destinations beyond LEO.

6CS1 Conduct the Earth Orbit Capability (Spiral 1) Systems Requirements Review to define detailed interface requirements for the Crew Exploration Vehicle, the Crew Launch Vehicle, and supporting ground and in-space systems.

6CS2 Competitively award contract(s) for Phase A and Phase B design and flight demonstration of the Crew Exploration Vehicle.

6CS3 Develop detailed Crew Launch Vehicle design and operational modifications to support human rating and exploration mission architecture requirements.

6CS4 Develop a plan for systems engineering and integration of the exploration System of Systems; clearly defining systems and organizational interfaces, management processes, and implementation plans.

Efficiency Measures

6CS5 Complete all development projects within 110% of the cost and schedule baseline.

6CS6 Increase annually the percentage of ESR&T and HSR&T technologies transitioned to Constellation Systems programs.

Program Management

The Constellation Systems Theme Director is Garry M. Lyles.

Quality

Independent Reviews:

- A pre-Non-Advocate Review (NAR) for the Earth Orbit Capability Program.
- Independent Cost Estimate for the Earth Orbit Capability program.

Program Assessment Rating Tool (PART):

The Office of Management and Budget has not yet conducted a PART review of the Constellation Systems Theme.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Constellation Systems	**911.4**	**526.0**	**594.1**	**1,120.1**	
Earth Orbit Capability (Spiral 1)	911.4	526.0	594.1	1,120.1	

Theme: Constellation Systems
Program: Earth Orbit Capability (Spiral 1)

President's FY 2006 Budget Request

(Dollars in Millions)

Earth Orbit Capability (Spiral 1)	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	911.4	526.0	1,120.1	1,579.5	1,523.7	1,990.9	2,452.2

Overview

The Earth Orbit Capability (Spiral 1) program is responsible for developing, demonstrating, and deploying the capability for crew transportation to Earth orbit. Systems include the Crew Exploration Vehicle (CEV), the Crew Launch Vehicle (CLV), and supporting ground and in-space systems. Earth Orbit Capability is the first spiral in a well-defined spiral development process. Spiral 1 will demonstrate crew transportation capability to Earth orbit by 2014 and will verify crew CEV and CLV readiness to support the Spiral 2 mission to the Moon. The following Spiral 2 program will develop, demonstrate, and deploy the additional capability to support human missions to the lunar surface no later than 2020. The Earth Orbit Capability (Spiral 1) program will enable the development and demonstration of power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and longer duration human and robotic exploration of the Moon, Mars, and other destinations.

The Earth Orbit Capability (Spiral 1) program will provide capabilities critical to the Vision for Space Exploration.

This program supports Objective 7.1. For more information, see http://exploration.nasa.gov/constellation/index.html.

Plans For FY 2006

Primary activities within the Earth Orbit Capability (Spiral 1) program include a CEV Systems Requirements Review; a CLV Broad Agency Announcement; the selection of a Lead Systems Integrator; and Directorate and Agency level approval for the Earth Orbit Capability (Spiral 1) program to begin the Concept Development and Preliminary Design phase.

Changes From FY 2005

- The Earth Orbit Capability (Spiral 1) program is a new program formulated to develop capabilities necessary to implemet the Vision. This porgram will assure optimum integration of the CEV and CLV.

Program Management

The Earth Orbit Capability (Spiral 1) program is managed at NASA Headquarters with support from all NASA Centers through Integrated Discipline Teams.

Theme: Constellation Systems
Program: Earth Orbit Capability (Spiral 1)

Technical Description

The objective of the Earth Orbit Capability (Spiral 1) program is to develop, demonstrate, and deploy the capability to safely transport a crew to Earth orbit, conduct on-orbit test and checkout demonstrations to prepare for missions to the Moon, and safely return the crew to Earth. The program will develop and integrate major systems including the CEV, the CLV, and the supporting ground and in-space systems required to meet orbital mission objectives. These integrated systems will perform the functions of transporting the crew from the ground to Earth orbit, providing a habitable crew environment for the mission duration, conducting on-orbit maneuvers as required, reentering Earth's atmosphere, and safely recovering the crew.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Constellation Systems Lead Systems Integrator								The Lead System Integrator is responsible for overseeing integration of all Constellation Systems into an overall System of Systems.	Tech Form Dev Ops Res	Jan-04 Oct-05	Sep-05 Dec-20
Crew Exploration Vehicle								The Crew Exploration Vehicle is an element of the System of Systems in which the crew is transported.	Tech Form Dev Ops Res	 Oct-03 Oct-05	 Sep-05 Dec-14
Crew Launch Vehicle								The Crew Launch Vehicle is the launch vehicle designed to launch the CEV into orbit; it may also be used for the launching of cargo.	Tech Form Dev Ops Res	 Jan-04 Oct-06 Oct-03	 Sep-06 Dec-14 Sep-05
Orbital Express								Orbital Express is joint project with DARPA to launch in 2005. It will demonstrate Autonomous Rendezvous and Docking and fluid and equipment transfer between uncrewed vehicles in orbit.	Tech Form Dev Ops Res	 Oct-03 Oct-04	 Sep-05 Sep-05
DART								DART is launching in 2005 to rendezvous with an existing satellite and demonstrate techniques and technologies applicable to an autonomous rendezvous and docking capability.	Tech Form Dev Ops Res	 Oct-03 Oct-04	 Sep-05 Sep-05

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

Strategy For Major Planned Acquisitions

- FY 2005 - Constellation Systems will award the contract for Phase 1 of the CEV Development effort (formulation to Preliminary Design Review, with a risk-reduction flight in 2008).
- FY 2005 - The program will development and release a Request for Proposal (RFP) for the Lead Systems Integrator for Constellation Systems. A contract based on this RFP will be awarded in FY 2006.

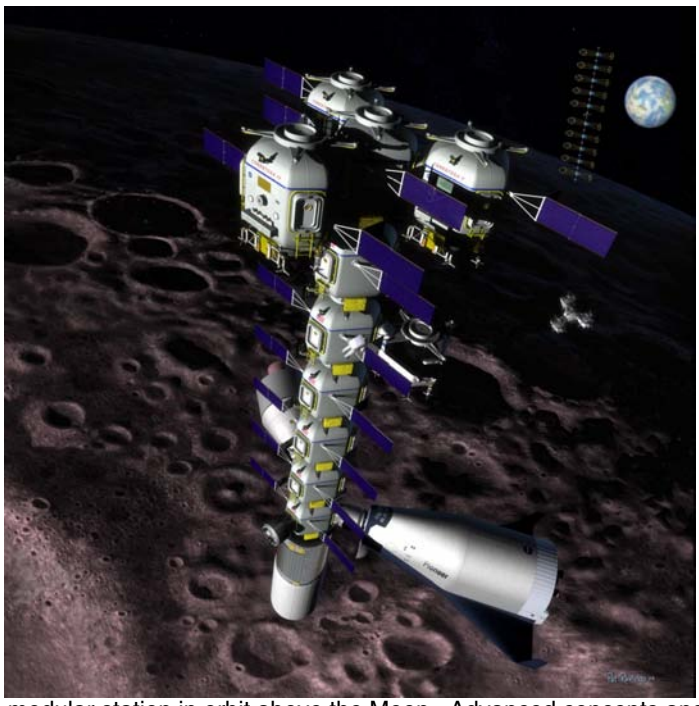
Key Participants

- Eleven Concept Exploration and Refinement study teams from industry and academia to develop innovative architectural solutions for lunar exploration and concepts for the CEV.
- NASA Centers will be fully integrated in this program through their participation in Integrated Discipline Teams; a NASA Center will play a significant role in the future Systems Engineering and Integration effort; and industry participants will be vital in the development of the CEV and CLV.

Risk Management

- RISK: Key technical risks include: human-rating the crew launch vehicle; developing reentry control and heating technologies; and ensuring CEV extensibility to the next spiral (lunar surface missions). MITIGATION: Technical risks will be mitigated by competitive CEV prime contracts through risk reduction flight demonstrations by 2008. Demonstrations will address key technical risks, including ascent flight abort system and/or reentry control. Launch vehicle interface and human rating requirements will be developed by the government systems engineering and integration and the CEV prime contractors.

Exploration System s Research and Technology



A modular station in orbit above the Moon. Advanced concepts and technologies such as these are being developed by the Exploration Systems Research and Technology Theme.

President's FY 2006 Budget Request (Dollars in Millions)

Exploration Systems Research and Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	676.6	722.8	919.2	907.3	989.2	1,050.3	1,078.5
Changes from FY 2005 Request	-21.3	48.6	9.9	-3.9	17.5	14.3	

Overview: *What* NASA Accomplishes through the Exploration Systems Research and Technology Theme

The Exploration Systems Research and Technology (ESR&T) Theme represents NASA's commitment to investing in the technologies that will make the ambitious goal of a safe, affordable, effective, and sustainable human-robotic exploration program possible. Working with NASA and non-NASA researchers and technologists, through focused investments and innovative partnerships, the ESR&T Theme will use competitive processes to advance a range of high-leverage technologies and space operations concepts, mature and validate key technologies, and transition them into future missions in Exploration Systems and other NASA Mission Directorates. The ESR&T Theme will work closely with other government agencies, industry, and academia to leverage common requirements and identify innovative ideas.

The ESR&T Theme is composed of four programs: the Advanced Space Technology program leads the exploratory research and development of new high-leverage technologies and concepts, and transitions them to the Technology Maturation program; the Technology Maturation program develops and validates novel system concepts for human-robotic exploration, and assures their timely transition into all NASA development programs; the Innovative Partnerships program enables the creative use of intellectual assets both inside and outside of NASA to meet Agency technology needs and benefit the Nation; the Centennial Challenges program establishes purse awards to stimulate innovative technical accomplishments.

Theme: Exploration Systems Research and Technology

Relevance: *Why* NASA conducts Exploration Systems Research and Technology work

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

By identifying, developing, and transitioning new technologies that have broad potential to enable novel systems concepts and capabilities, the ESR&T Theme makes a unique contribution to NASA's goal of expanding human presence into the solar system for exploration and discovery, while assuring a robust foundation of crosscutting technology for the broad spectrum of future NASA space missions.

Relevance to the NASA mission:

The ESR&T Theme supports the Vision for Space Exploration by developing the innovative technologies needed to implement a sustained and affordable human and robotic program to explore the solar system and beyond.

Relevance to education and public benefits:

NASA plans to partner extensively in the implementation of the program, including significant reliance on the expertise of academia in research and development efforts. This will provide educational opportunities to undergraduate and graduate students in U.S. colleges and universities. In addition, by advancing diverse, novel technologies through projects with non-traditional NASA research partners, small businesses and others, public benefits from ESR&T will include new technologies for use in industry and by the general public.

Performance

Major Activities Planned for FY 2006:

- Complete Phase I of Advanced Space Technology and Technology Maturation projects and initial validation of new concepts and technologies.
- Broad Agency Announcement to fill critical technology gaps for development of the Crew Exploration Vehicle (Spiral 1) and the first human lunar landing missions (Spiral 2).
- Assess and address critical in-house capabilities and technology gaps.

Major Recent Accomplishments:

- FY 2004 - Formulated new ESR&T programs to support the Vision for Space Exploration.
- FY 2004 - Competitively selected 48 intramural technology development projects performed by the NASA Centers.
- FY 2004 - Competitively selected 70 extramural technology development projects via a Broad Agency Announcement.
- FY 2004 - Completed National Academy of Public Adminstration (NAPA) review of NASA technology transfer approach and programs.
- FY2004 - Realigned Research Partnership Centers (part of the Space Product Development effort) to better conduct research that directly contributes the NASA mission.

Theme: Exploration Systems Research and Technology

Exploration Systems Research and Technology Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

11. Develop and demonstrate power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations.

11.3 By 2015, identify, develop, and validate human-robotic capabilities required to support human-robotic lunar missions.

6ESRT5 Validate the ESMD research and technology development needs and opportunities by implementing a Quality Function Deployment process, and use the results to guide ESR&T program investment decisions.

6ESRT6 Develop and analyze affordable architectures for human and robotic exploration system and mission options using innovative approaches such as modular systems, in-space assembly, pre-positioning of logistics, and utilization of in-situ resources.

11.4 By 2015, identify and execute a research and development program to develop technologies critical to support human-robotic lunar missions.

6ESRT4 Design and test technologies for in situ resource utilization that can enable more affordable and reliable space exploration by reducing required launch mass from Earth, and by reducing risks associated with logistics chains that supply consumables and other materials. Technology development includes excavation systems, volatile material extraction systems, and subsystems supporting lunar oxygen and propellant production plants.

6ESRT7 Identify and define technology flight experiment opportunities to validate the performance of critical technologies for exploration missions.

11.6 Develop and deliver one new critical technology every two years in each of the following disciplines: in-space computing, space communications and networking, sensor technology, modular systems, robotics, power, and propulsion.

6ESRT1 Identify and test technologies to enable affordable pre-positioning of logistics for human exploration missions. Technology development includes high power electric thrusters and high efficiency solar arrays for solar electric transfer vehicles, and lightweight composite cryotanks and zero boil-off thermal management for in-space propellant depots.

6ESRT2 Identify and test technologies to enable in-space assembly, maintenance, and servicing. Technology development includes modular truss structures, docking mechanisms, micro-spacecraft inspector, intelligent robotic manipulators, and advanced software approaches for telerobotic operations.

6ESRT3 Identify and test technologies to reduce mission risk for critical vehicle systems, supporting infrastructure, and mission operations. Technology development includes reconfigurable and radiation tolerant computers, robust electronics for extreme environments, reliable software, and intelligent systems health management.

6ESRT8 Identify and test technologies to reduce the costs of mission operations. Technology development includes autonomous and intelligent systems, human-automation interaction, multi-agent teaming, and space communications and networking.

Theme: Exploration Systems Research and Technology

11.7 Promote and develop innovative technology partnerships, involving each of NASA's major R&D programs, among NASA, U.S. industry, and other sectors for the benefit of Mission Directorate needs.

6ESRT9 Complete 50 technology transfer agreements with the U. S. private sector for transfer of NASA technologies, hardware licenses, software usage agreements, facility usage agreements or Space Act Agreements.

6ESRT10 Develop 40 industry partnerships that will add value to NASA missions.

6ESRT11 Establish at least twelve new partnerships with major ESMD R&D programs or other NASA organizations.

11.8 Annually facilitate the award of venture capital funds or Phase III contracts to no less than two percent of NASA-sponsored Small Business Innovation Research (SBIR) Phase II firms to further develop or produce their technology for industry or government agencies.

6ESRT12 Award Phase III contracts or venture capital funds to 4 SBIR firms to further develop or produce technology for U. S. industry or government agencies.

Efficiency Measures

6ESRT13 Complete all development projects within 110% of the cost and schedule baseline.

6ESRT14 Peer review and competitively award at least 80%, by budget, of research projects.

6ESRT15 Reduce annually, the time to award competed projects, from proposal receipt to selection.

Program Management

The ESR&T Theme Director is John C. Mankins.

Quality

Independent Reviews:

- National Research Council review of ESR&T formulation plan and review of first year of new program direction.
- Report by a panel of the National Academy of Public Administration, "Technology Transfer, Bringing Innovation to NASA and the Nation"
- Independent Review of the Research Partnership Centers conducted by Booz-Allen Hamilton.

Program Assessment Rating Tool (PART):

OMB has not yet conducted a PART review of the Exploration Systems Research and Technology Theme.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Exploration Systems Research and Technology	**676.6**	**722.8**	**196.4**	**919.2**	
HST Deorbit Mission		89.0	-89.0		
Advanced Space Technology	455.8	325.7	29.9	355.6	
Technology Maturation	3.0	110.2	196.3	306.4	
Innovative Partnerships	217.9	188.3	34.9	223.2	
Centennial Challenges		9.7	24.3	34.0	

The change in the HST Deorbit Mission reflects a transfer of the responsibility for the mission to the Science Mission Directorate.

Theme: Exploration Systems Research and Technology
Program: Advanced Space Technology

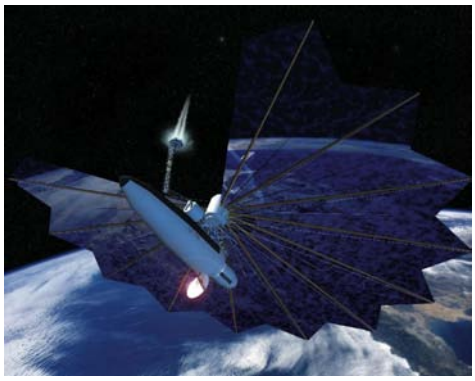
President's FY 2006 Budget Request

(Dollars in Millions)

Advanced Space Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	455.8	325.7	355.6	347.3	368.1	353.6	364.6

Overview

The Advanced Space Technology (AST) program develops new technologies that will enable NASA to conduct new human and robotic exploration missions, gather new types of scientific data, and reduce mission risk and cost. The primary customers of these technologies are the Exploration Systems Mission Directorate and other NASA Mission Directorates. The advanced system concepts, fundamental technologies, and engineering tools developed by the program are unique to NASA needs, and applicable across many classes of missions. Accordingly, the research activities in the Advanced Space Technology program are organized into five major technical areas that are fundamentally critical to all NASA missions: Advanced Studies, Concepts, and Tools; Advanced Materials and Structural Concepts; Computing, Communications, Electronics, and Imaging; Power, Propulsion, and Chemical Systems; and Software, Intelligent Systems, and Modeling. The program consists of a broad portfolio of exploratory research and development projects performed by the NASA Centers and external organizations. The program began in 2004 with the competitive selection of 34 intramural projects and 51 extramural projects. By 2008, these projects will develop proof-of-concept components and subsystems that will impact NASA missions in 2014 and beyond. Technology products are transitioned to the Technology Maturation Program for integration into representative systems, and validation in ground and space experiments. This program supports Objectives 11.3 and 11.6. For more information, see http://exploration.nasa.gov/programs/systems.html.



A solar electric transfer vehicle could be used to affordably transport propellants and other cargo from Earth orbit to staging points near the Moon and Mars. The Advanced Space Technology program develops a broad portfolio of fundamental technologies to enable innovative system concepts like this, including high power electric thrusters, high efficiency solar cells, and lightweight deployable structures.

Plans For FY 2006

Identify and test technologies to enable affordable pre-positioning of logistics for human exploration missions. Solar electric transfer vehicles and in-space propellant depots could allow more affordable mission architectures. Technology development includes high power electric thrusters, high efficiency solar arrays, lightweight composite cryotanks, and zero boil-off thermal management.

Identify and test technologies to enable in-space assembly, maintenance, and servicing. This capability could reduce mission cost by allowing standardized modular systems that can be flown on existing launch vehicles and reconfigured for different mission applications. Technology development includes modular truss structures, docking mechanisms, intelligent robotic manipulators, and advanced approaches for telerobotic operations.

Identify and test technologies to reduce mission risk for critical vehicle systems, supporting infrastructure, and mission operations. Technology development includes reconfigurable and radiation tolerant computers, robust electronics for extreme environments, reliable software, and intelligent systems for health management.

Identify and test technologies to enable sustainable human presence on the Moon. Technology development includes chemical processes to extract oxygen from lunar regolith, regenerative fuel cells and high enery density batteries to provide abundant power, and fabric materials for advanced spacesuits and inflatable habitats.

Changes From FY 2005

- Completed legacy projects from former Mission and Science Measurement Technology Theme that were transferred to Exploration Systems Research and Technology.

Program Management

The Advanced Space Technology program is managed by a team in the Exploration Systems Mission Directorate at NASA Headquarters.

Technical Description

The main technical challenges that the AST program addresses are reducing mission risk and cost. The program reduces mission risk by developing advanced engineering tools, space-durable materials, radiation tolerant electronics, reconfigurable computers, reliable software, and intelligent systems for health management.

The AST program reduces mission cost by developing technologies to enable in-space assembly and maintenance, such as modular structures, docking mechanisms, intelligent robots, and telerobotic operations approaches. The program also develops technologies to enable the affordable pre-positioning of logistics, such as electric thrusters and solar arrays for cargo transfer vehicles, and composite cryotanks and thermal management for in-space propellant depots.

Theme: Exploration Systems Research and Technology
Program: Advanced Space Technology

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Advanced Studies, Concepts, & Tools								Development of advanced systems concepts and systems analysis tools; advanced studies to identify and prioritize technology needs.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04
Advanced Materials & Structural Concepts								Development of high-performance materials; advanced mechanisms; space environments and effects models; structural concepts for deployment and modular assembly.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04
Computing, Communications, Electronics and Imaging								Development of in-space computing; space communications and networking; electronics for extreme environments; sensing and imaging for exploration systems.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04
Power, Propulsion, & Chemical Systems								Development of energy conversion, energy storage, power management and distribution; chemical and electrical propulsion; thermal management; chemical systems for processing in-situ resources	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04
Software, Intelligent Systems, and Modeling								Development of reliable software; intelligent systems for robotics, space operations, and systems health management; human-autonomy interaction; simulation and modeling approaches.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04

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

Strategy For Major Planned Acquisitions

- A Broad Agency Announcement for new extramural technology projects to refresh current portfolio following Phase I termination reviews.

Key Participants

- Industry, universities, and other government agencies perform 51 competitively selected and peer reviewed extramural technology development projects in partnership with NASA Centers.
- NASA Centers perform competitively awarded and peer reviewed intramural technology development projects in partnership with external organizations.

Risk Management

- RISK: Selected technology development projects will not progress as anticipated. MITIGATION: The program will implement Earned Value Management to track progress versus plans; Annual continuation reviews.
- RISK: Difficulty in transitioning developing technologies to potential users. MITIGATION: Joint funding of technology transition activites is required to insure users are committed to infusing technology products into mission applications. The program will validate technologies in ground and space experiments conducted by the Technology Maturation program.
- RISK: Changes in requirements for technology development. MITIGATION: The program will invest in broad portfolio of technologies and will continually update requirements with systems analysis and through interaction with the Exploration Systems Requirements Division and CEV contractor teams.
- RISK: Lack of portfolio flexibility. MITIGATION: The program will prioritize descope options, maintain adequate program budget reserves, and require personnel and facility commitments in project plans.

Theme: Exploration Systems Research and Technology
Program: Technology Maturation

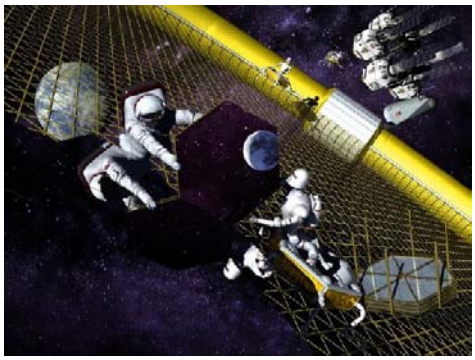
President's FY 2006 Budget Request

(Dollars in Millions)

Technology Maturation	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	3.0	110.2	306.4	307.9	388.9	475.2	483.0

Overview

The goals of enabling human presence and activity beyond low Earth orbit are particularly challenging and demand a robust, ongoing commitment to innovation and new technology development. The Technology Maturation program develops and validates the most promising advanced space technology concepts and matures them to the level of demonstration and space flight validation to enable safe, affordable, effective, and sustainable human-robotic exploration. Within the program, technologies that are emerging from NASA's Advanced Space Technology program and other NASA and non-NASA advanced technology programs are matured from moderate readiness to high levels of readiness for transition to Constellation Systems and other applications. This new NASA program began in 2004 with the competitive solicitation of 33 Phase I pilot projects, 14 of which are led by NASA Centers and 19 of which are led by external organizations. The projects are in five major areas: Advanced Space Operations; Advanced Space Platforms and Systems; High-Energy Space Systems; Lunar and Planetary Surface Operations; and In-Space Technology Experiments. This program supports Objectives 11.4 and 11.6. For more information, please see http://exploration.nasa.gov/programs/systems.html.



Humans and robots are working together to assemble a large space structure. The Technology Maturation program develops and demonstrates new technologies and systems to enable a broad array of capabilities such as in-space assembly, maintenance, and servicing.

Plans For FY 2006

- Identify and test Integrated System Health Management (ISHM) technologies that could improve reliability and effectiveness for launch vehicles and in-space systems. Incorporation of ISHM software and sensors has the potential of improving automated and manual response to anomalous conditions. Technology development includes multiple Client Application software technologies that could be used in the Crew Exploration Vehicle or other space systems.

- Identify and test technologies and systems that improve the affordability and safety of space systems through improved in-space assembly and repair capabilities. Technology development includes micro-inspector spacecraft, teleoperated robotic maintenance systems, and advanced mating technologies that enable low-kinetic energy docking and berthing.

- Design and test technologies for space resource utilization. Use of in situ resources can enable more affordable and reliable space exploration by reducing required launch mass from Earth and by reducing risks associated with "logistics supply trains" such as consumables and other materials. Technologies include excavation subsystems, volatile material extraction subsystems, and subsystems supporting lunar oxygen/propellant production plants.

- Identify and test advanced subsystems supporting affordable in-space transportation and power generation that are extensible to space exploration beyond near-Earth space. Technology development includes lightweight, high-efficiency solar power technologies; advanced electric propulsion systems that are scaleable to cargo transfer and human spacecraft; and cryogenic fluid management subsystems for propellant storage depots.

Changes From FY 2005

- 33 Phase I, pilot projects were initiated during FY 2005. During FY 2006, many of these projects will be transitioned to Phase II and new projects will be added with a focus on near-term needs.

Program Management

The Technology Maturation program is managed by a team in the Exploration Systems Mission Directorate at NASA Headquarters.

Technical Description

The ESR&T Technology Maturation Program, comprising mid- to high-readiness technology maturation, demonstration and flight experiments, pursues new technologies that have the potential to improve the affordability, reliability, safety, and effectiveness of space systems. Investment topics include high-efficiency, low-mass solar power generation systems; high-efficiency, high-power and low -mass electromatnetic propulsion systems; intelligent reconfigurable modular systems; robust and reconfigurable habitation systems; space assembly, maintenance and servicing systems; reliable and responsive ground operations systems; intelligent and agile surface mobility systems; in-situ resource utilization systems; and lunar/planetary surface manufacturing and construction systems.

Theme: Exploration Systems Research and Technology
Program: Technology Maturation

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Advanced Space Operations								Technology maturation for space assembly, maintenance, and servicing systems; intelligent onboard operations systems; ground operations systems.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-10 Sep-04
Advanced Space Platforms and Systems								Technology maturation for integrated systems health management; intelligent modular systems; habitation systems; communications networks.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04
High Energy Space Systems								Technology maturation for solar power generation systems; cryogenic propellant refueling systems; electric propulsion systems; in-space cryogenic rocket engines; aero-assist systems.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04
Lunar and Planetary Surface Operations								Technology maturation for surface mobility systems; in-situ resource utilization systems; surface manufacturing and construction systems; surface environmental management systems.	Tech Form Dev Ops Res	Oct-04 Oct-03	Apr-20 Sep-04
In-Space Technology Experiments Program								Definition, development, and execution of flight experiments to validate new technologies for exploration missions.	Tech Form Dev Ops Res	Oct-04 Oct-03	Dec-20 Sep-04

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

Strategy For Major Planned Acquisitions

- Broad Agency Announcement for competitive, peer reviewed, extramural technology projects performed by industry, universities, and other government agencies in partnership with NASA Centers.

Key Participants

- Industry, universities, and other government agencies perform 19 competitively selected and peer reviewed extramural technology development projects in partnership with NASA Centers.
- NASA Centers perform 14 competitively selected and peer reviewed intramural technology development projects in partnership with external organizations.

Risk Management

- RISK: Selected technology development projects will not progress as anticipated. MITIGATION: The program will implement Earned Value Management to track progress versus plans and perform annual continuation reviews.
- RISK: Difficulty in transitioning developing technologies to potential users. Likelihood is moderate. MITIGATION: Joint funding of technology transition activites is required to insure users are committed to infusing technology products into mission applications. The program will validate technologies in ground and space experiments conducted by the Technology Maturation program.
- RISK: Changes in requirements for technology development. MITIGATION: The program will invest in broad portfolio of technologies and will continually update requirements with systems analysis and through interaction with the Exploration Systems Requirements Division and CEV contractor teams.
- RISK: Lack of portfolio flexibility. MITIGATION: The program will prioritize descope options, maintain adequate program budget reserves, and require personnel and facility commitments in project plans.

Theme: Exploration Systems Research and Technology
Program: Innovative Partnerships

President's FY 2006 Budget Request

(Dollars in Millions)

Innovative Partnerships	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	217.9	188.3	223.2	227.0	222.2	221.4	230.9

Overview

The Innovative Partnerships program consists of the following actiivities: Technology Transfer; Space Product Development; University Research and Engineering Institutes; Small Business Innovative Research projects; and Small Business Technology Transfer progjects.

Small Business Innovation Research is a congressionally mandated activity that has as its purpose the development of innovative technology that can make important contributions to NASA's mission and vision.

Small Business Technology Transfer Research is a congressionally mandated activity that leverages the innovation of U.S. research institutions in conjunction with small business.

Technology Transfer projects develop strategies and executes plans to seek and acquire vital technologies from U.S industry to help support NASA programs in achieving their science and mission objectives.

NASA's Innovative Partnerships program is committed to developing partnerships among industry, government, and academia to effectively accomplish the Vision and deliver benefits to the people of Earth.

Space Product Development activity seeks to advance NASA's mission and develop opportunities for commerce in space through research partnerships. This program element is carried out through Research Partnership Centers, a consortia of government, industry, and academia conducting dual use research.

The University Research and Engineering Technology Institutes provide strengthened ties to the academic community through long-term sustained investment in areas of innovative and long-range technology critical to NASA's future.

This program supports Objectives 11.7 and 11.8. For more information see http://ipp.nasa.gov.

Theme: Exploration Systems Research and Technology
Program: Innovative Partnerships

Plans For FY 2006

Significant attention will be focused on reviewing and integrating the separate activities of the Innovative Partnerships prorgram into one cohesive and effective portfolio of investment. Specifically the program will accomplish the following:

-Integrate all Innovative Partnership program elements to reduce duplication, maximize synergy, and promote overall effectiveness.

-Centralize External Contractor Network for management of NASA Technology Transfer projects at NASA Headquarters, and implement other recommendations of the National Academy of Public Administration (NAPA)report, "Technology Transfer, Bringing Innovation to NASA and the Nation."

Much of this effort will begin in FY 2005, but work on new Technology Transfer projects (under the new management structure) will not begin until FY 2006, and the implementation of all recommendations in the NAPA report will necessarily continue through FY06.

Program Management

The Innovative Partnership program is managed by a team in the Exploration Systems Mission Directorate at NASA Headquarters.

Technical Description

The program focuses on providing technological solutions for meeting NASA's needs by seeking technologies from within NASA and from other federal agencies, U.S. industry, and academia. The Space Product Development effort is carried out through Reseach Partnership Centers - a consortia of industry, government, and academia that conduct dual use research that benefits the NASA mission as well as the public. Both Small Business efforts leverage the innovation of the small business community. Within the University Research and Engineering Technology Institutes, Institute is comprised of a cluster of research Universities and/or NASA Centers with one University as the lead organization.

Theme: Exploration Systems Research and Technology
Program: Innovative Partnerships

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Small Business Innovative Research								Small Business Innovation Research fosters innovative technology development, increases small business participation in federal projects, and enhances private sector commercialization.	Tech Form Dev Ops Res	Oct-03	Dec-20
Small Business Technology Transfer Research								Small Business Technology Transfer Research leverages the innovation of U.S. research institutions in conjunction with small business.	Tech Form Dev Ops Res	Oct-03	Dec-20
Technology Transfer								Technology Transfer develops strategies to seek and acquire vital technologies from U.S industry to support NASA missions, and makes NASA technologies available to the private sector.	Tech Form Dev Ops Res	Oct-03	Dec-20
Space Product Development								Space Product Development sponsors partnerships involving consortia of government, industry, and academia to conduct dual use research.	Tech Form Dev Ops Res	Oct-03	Dec-20
University Research and Technology Institutes								University Research and Technology Institutes are grants for basic research in nanotechnology. Agreements expire in 2007 as initially planned.	Tech Form Dev Ops Res	Oct-03	Sep-07

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

Strategy For Major Planned Acquisitions

- Small Business Innovative Research and Small Business Technology Transfer Research awards will be granted per the usual award cycle.

Key Participants

- Small business, industry, universities, state and local government agencies

Theme: Exploration Systems Research and Technology
Program: Centennial Challenges

President's FY 2006 Budget Request

(Dollars in Millions)

Centennial Challenges	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		9.7	34.0	25.0	10.0		

Overview

The Centennial Challenges program conducts prize competitions for revolutionary, breakthrough accomplishments that advance solar system exploration and other NASA priorities. Some of NASA's most difficult technical challenges may require novel solutions from non-traditional sources of innovations. By making awards based on actual achievements instead of proposals, NASA hopes to tap innovators in academia, industry, and the public that do not normally work on NASA issues. Centennial Challenges is modeled on successful past prize competitions, including an 18th century navigation prize, early 20th century aviation prizes, and more recent prizes offered by the U.S. government and in the private sector.

For more information see:
http://exploration.nasa.gov/centennialchallenge/cc_index.html

Plans For FY 2006

Centennial Challenges plans to prepare and announce at least three new prize competitions in FY 2006.

Changes From FY 2005

- Centennial Challenge major award purses have been delayed because pending legislation to authorize challenge purses in excess of $250,000.00.

Program Management

The Centennial Challenges Program is managed at NASA Headquarters by the Exploration Systems Mission Directorate.

Theme: Exploration Systems Research and Technology
Program: Centennial Challenges

Technical Description

- Centennial Challenges issues prize competitions, or challenges, in key technical areas supporting the Vision for Space Exploration. Prize purses for each challenge remain available until awarded or for the duration of that challenge. Challenges are open to U.S. citizens who are not government employees or as otherwise detailed in the eligibility rules of the individual challenge.

- Centennial Challenges has and will continue to conduct workshops to solicit new challenges ideas. Centennial Challenges works closely with other NASA programs to ensure that individual challenges align with NASA goals. Challenges are planned in the areas of low-cost robotic space missions; highly mobile, capable and survivable robotic systems; and fundamental advances in key spacecraft technologies.

Strategy For Major Planned Acquisitions

- Centennial Challenges plans to renew or re-compete support contracts for the administration of Centennial Challenge prize competitions in FY 2006.

Key Participants

- Key participants in the Centennial Challenges program include the teams that compete for various prizes, support contractors that help administer individual prize competitions, and partners that contribute funding or in-kind resources to individual prize competitions.

Risk Management

- RISK: A key risk for Centennial Challenges is the overhead costs associated with administering prize competitions. MITIGATION: To ensure that these overhead costs do not overwhelm budget resources available for prizes, the Centennial Challenges program carefully considers overhead costs when constructing the rules for each prize competition and employs best techniques to monitor and manage support contracts for prize administration.

Prometheus Nuclear Systems and Technology

NASA's ability to explore the Solar System will be enhanced by the nuclear systems developed by Prometheus Nuclear Systems and Technology.

President's FY 2006 Budget Request (Dollars in Millions)

Prometheus Nuclear Systems and Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		431.7	319.6	423.5	500.6	614.0	779.0
Changes from FY 2005 Request		-6.2	-109.4	-1.5	74.6	190.0	

Overview: *What* NASA Accomplishes through the Prometheus Nuclear Systems and Technology Theme

Prometheus Nuclear Systems and Technology focuses on research and development of advanced nuclear energy systems to enable future space exploration. The Theme also funds research in supporting power and propulsion systems, materials development, integrated spacecraft systems, and other capabilities. Nuclear energy would enable significantly expanded space exploration capabilities by offering substantially greater power than previously developed systems and significant future growth in areas such as spacecraft propulsion, communications, maneuverability, endurance, and scientific instrument capabilities.

An investigation of Jupiter's icy moons will not be the first demonstration for Prometheus Nuclear Systems and Technology, as concerns over costs and technical complexity prompted NASA to defer the Jupiter Icy Moons Orbiter mission. NASA is now conducting a Prometheus Analysis of Alternatives to identify a mission relevant to exploration and scientific goals, with reduced technical, schedule, and operational risk.

NASA will work with its partners at the Department of Energy to develop these new technologies, materials, and engineered systems through agreements and working partnerships with the Department of Energy Office of Naval Reactors (DOE-NR) and Nuclear Energy (DOE-NE). DOE-NR is NASA's partner in developing the space nuclear fission reactor while DOE-NE is NASA's partner in research and technology development of second generation space nuclear power technologies.

Theme: Prometheus Nuclear Systems and Technology

Relevance: *Why* NASA conducts Prometheus Nuclear Systems and Technology work

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

The research and infrastructure used to develop reactor fuels and power systems at a high power and temperature level suitable for advanced space robotic and human exploration offers the prospect for improvements and applications to other missions in space and on Earth. Research to develop reactor fuels and power systems suitable for advanced space robotic and human missions enabled by Prometheus will be applicable to a range of missions in space and here on Earth. Additionally, the work funded by NASA would enable revitalization of the nation's nuclear engineering and research infrastructure.

The partnership created by NASA with DOE NR and the aerospace industry brings together three diverse technical communities and cultures: the spacecraft design and mission operations community, the nuclear reactor design, development, and operations community, and the technology development, large-scale spacecraft engineering community. Merging these communities is essential and will lead to improved communication and sharing of methodologies for testing, modeling, and analysis. This partnership will improve the level of understanding between different communities on various approaches to the design, manufacture, and operation of complex technical systems.

Relevance to the NASA mission:

In Earth orbit solar energy is sufficient to power current systems that enable human activity in space. New exploration missions will have requirements exceeding what solar power can provide, particularly for surface and outer planet applications. Prometheus systems can solve problems posed by these missions that have no other practical solution.

Relevance to education and public benefits:

In the 2002 Science and Engineering Indicators published by the National Science Foundation, the needs of the nuclear engineering and commercial nuclear energy industry were identified as key communities that are in need of new capabilities, and more importantly, a new generation of scientists and engineers to maintain the systems and perform the work. Prometheus will inspire a new generation of scientists and engineers from a very broad range of disciplines, and will fund research programs in universities with engineering and science departments, thus increasing the talent pool that may be attracted to these industries. Therefore, Prometheus-funded efforts in advanced power conversion and power generation will enable expanded university-based research programs.

Prometheus has incorporated processes and plans to build public trust in NASA's stewardship of nuclear technologies. Prometheus incorporates plans for communications, engagement, and outreach activities designed to inform the public about the program and these technologies within the broader context of the Vision, and with DOE's assistance, is seeking to build public trust in NASA's stewardship of this technology.

Theme: Prometheus Nuclear Systems and Technology

Performance

Major Activities Planned for FY 2006:

- Following completion of the Prometheus Analysis of Alternatives, initiate preliminary design of a nuclear demonstration mission.
- Conduct technology development of structures, systems, and components for an initial nuclear technology demonstration.
- Conduct the "NASA Dialogue on Nuclear Energy for Space Exploration" to understand public concerns and engage diverse stakeholders in discussions on the need and uses of these technologies.
- Conduct advanced research and development and conceptual studies for follow-on and second generation missions and applications.

Major Recent Accomplishments:

- NASA and DOE-NR signed a Memorandum of Understanding for the development of nuclear space reactor.
- DOE-NR completed formulation of a development plan, schedule, and budget for a Prometheus 1 space reactor.
- Prometheus 1 Spacecraft Design and Integration contract was competitively awarded to Northrop Grumman Space Technologies (NGST). NGST is partners with NASA and DOE-NR in the design of Prometheus 1.
- Competitively awarded four contract teams and competitively selected four additional teams to conduct advanced nuclear electric propulsion technology research.

Prometheus Nuclear Systems and Technology Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

11. Develop and demonstrate power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations.

11.5 By 2016, develop and demonstrate in-space nuclear fission-based power and propulsion systems that can be integrated into future human and robotic exploration missions.

6PROM1 Following completion of the Prometheus Analysis of Alternatives, complete space nuclear reactor conceptual design.

6PROM2 Verify and validate the minimum functionality of initial nuclear electric propulsion (NEP) spacecraft capability.

6PROM3 Complete component level tests and assessments of advanced power conversion systems.

Efficiency Measures

6PROM4 Complete all development projects within 110% of the cost and schedule baseline.

6PROM5 Reduce annually, the time to award competed projects, from proposal receipt to selection.

Theme: Prometheus Nuclear Systems and Technology

Program Management

The Acting Theme Director is Mr. Ray Taylor.

Quality

Independent Reviews:

Program Assessment Rating Tool (PART):

OMB has not yet conducted a PART review of the Prometheus Nuclear Systems & Technology Theme.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Prometheus Nuclear Systems and Technology		**431.7**	**-112.1**	**319.6**	
Advanced Systems and Technology		54.8	-19.8	35.0	
Nuclear Flight Systems		376.9	-92.3	284.6	

Theme: Prometheus Nuclear Systems and Technology
Program: Advanced Systems and Technology

President's FY 2006 Budget Request

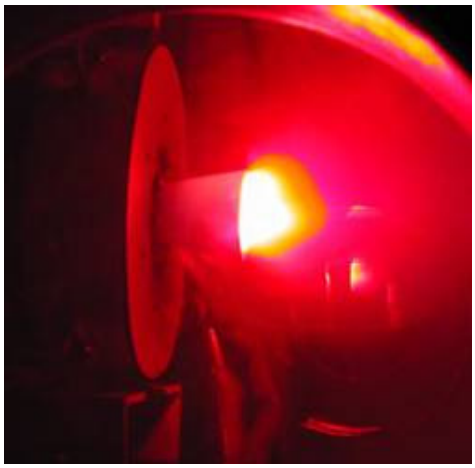
(Dollars in Millions)

Advanced Systems and Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		54.8	35.0	33.8	49.2	64.4	79.5

Overview

The Advanced Systems and Technology program develops and demonstrates advanced nuclear technologies and engineered systems necessary to support our goal of more distant, more ambitious, and longer duration human and robotic exploration of Mars and other destinations. Specifically, this program will conduct advanced research and development for follow-on and second generation advanced missions and applications that follow the first space nuclear mission. The program would build upon technology developed for initial Prometheus missions to develop systems with the performance necessary for crew or cargo vehicles to Mars and for other advanced exploration missions. This includes initial activities geared towards development of nuclear fission based power systems for robotic and human exploration.

This Program supports Objective 11.5. For more information see: http://exploration.nasa.gov/programs/prometheus.html.



The Lithium-fed Lorentz Force Accelerator being developed by a Princeton University led NRA team.

Plans For FY 2006

Conduct technology research and development activities for advanced nuclear electric propulsion and other power conversion systems, with component system level tests and assessments to be completed by 2006.

Changes From FY 2005

- Research in this program has been adjusted to reflect new priorities for the Theme, better aligning technology development with the results of the Analysis of Alternatives and ESMD requirements.

Program Management

The Advanced Systems and Technology program is managed at NASA Headquarters.

Theme: Prometheus Nuclear Systems and Technology
Program: Advanced Systems and Technology

Technical Description

The Advanced Systems and Technology program develops and demonstrates advanced nuclear technologies and engineered systems for missions and applications that follow the first nuclear demonstration mission. Key Advanced Systems and Technology program research areas include advanced nuclear electric propulsion, advanced fission-based power systems, advanced nuclear propulsion systems, and long-range nuclear reactor systems technology development. To the extent practical, Advanced Systems and Technology research will be peer-reviewed and competitively awarded. To ensure that these systems can be integrated into future human and robotic explorations missions, procurement task requirements will undergo a strategy-to-task-to-technology process.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Advanced Nuclear Electric Propulsion								Assess, research, and develop multiple advanced in-space propulsion technologies, including very high power nuclear electric systems to support future human exploration missions.	Tech Form Dev Ops Res	Oct-03	Sep-20
Advanced Fission-Based Power Systems								Assess, research, and develop multiple high-power thermal-to-electrical system technologies needed for electric propulsion and advanced power applications.	Tech Form Dev Ops Res	Oct-03	Sep-20
Advanced Nuclear Propulsion Systems								Assess, research, and develop advanced nuclear propulsion technologies needed to support future human exploration missions and applications.	Tech Form Dev Ops Res	Oct-04	Dec-10
Long-Range Reactor Systems Technology								Assess, research, and develop systems and fuel technologies for high power levels needed for advanced human and robotic applications in future exploration missions.	Tech Form Dev Ops Res	Oct-03	Sep-10

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

Strategy For Major Planned Acquisitions

- No new major acquisitions planned for FY2006.

Theme: Prometheus Nuclear Systems and Technology
Program: Nuclear Flight Systems

President's FY 2006 Budget Request

(Dollars in Millions)

Nuclear Flight Systems	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		376.9	284.6	389.8	451.4	549.6	699.5

Overview

The Nuclear Flight Systems program develops nuclear reactor power and associated systems that will enhance NASA's abilities to conduct exploration and science operations in the Solar System. These nuclear-powered systems will provide transformational and unprecedented capabilities that will significantly improve future exploration and science missions, including: more complex mission operations in space such as advanced maneuverability, active navigation, and high-powered science and surveying instrument operation; high band width communications to Earth; transportation of cargo for human support to exploration destinations; power generation for destination surface systems; or robust scouting missions in advance of human endeavors.

Testing of a High Power Electric Propulsion Thruster at Glenn Research Center

Upon completion of the Prometheus Analysis of Alternatives, the Nuclear Flight Systems program will initiate conceptual design of a space nuclear reactor demonstration. In support of this effort, the program maintains two interrelated activities. Through the Office of Naval Reactors, the program sponsors nuclear technology and engineering development activities necessary to develop a space-qualified nuclear reactor, beginning with conceptual design for a near-term demonstration. Concurrently, NASA is developing spacecraft structures, systems, and components that are suitable for integration with a high-power space nuclear reactor system. Products will be developed in a phased approach to accomodate increasing mission complexity, as appropriate to spiral development.

This program supports Objective 11.5. For more information see: http://exploration.nasa.gov/programs/prometheus.html.

Plans For FY 2006

Conduct technology development for Nuclear Electric Propulsion spacecraft structures, systems, and components.

Changes From FY 2005

- The JIMO mission will not be the first Prometheus demonstration. NASA is now conducting an Analysis of Alternatives to identify an alternative mission relevant to exploration and scientific goals.

Theme: Prometheus Nuclear Systems and Technology
Program: Nuclear Flight Systems

Program Management

The Nuclear Flight Systems Program is managed at NASA Headquarters, with the Promtheus 1 program office located at the Jet Propulsion Laboratory.

Technical Description

The Nuclear Flight Systems Program will develop technologies with unprecedented exploration and science capabilities. These include the ability to maneuver in space, operate high-powered science and surveying instruments, and provide high band-width communications to Earth. These robotic explorers will have sufficient power to ultimately be employed as robust pathfinders for scouting missions in advance of human endeavors in deep space.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Prometheus 1								The Prometheus-1 mission will serve to demonstrate the capabilities of a space nuclear reactor, as well as reduce risks associated with the development of future Prometheus missions.	Tech	Oct-03	Sep-05
									Form		
									Dev	Oct-05	Dec-20
									Ops		
									Res		

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

Strategy For Major Planned Acquisitions

- In 2006 no new major contracts are anticipated. Preliminary design for a new Prometheus 1 demonstration will be conducted, and reactor prototype development will be conducted under DOE-NR direction.

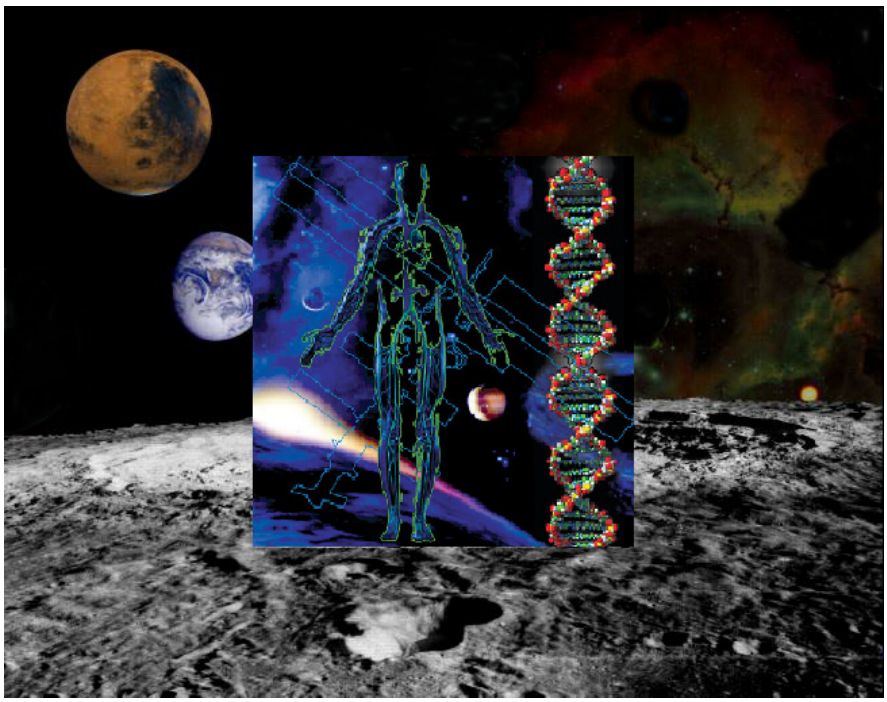
Key Participants

- Nuclear Flight Systems has partnered with the Department of Energy Office of Naval Reactors in the development of space nuclear reactor power plants.

Risk Management

- RISK: The key development and schedule risks for the Nuclear Flight Systems Program are the uncertanties in design and construction of a space nuclear fission power plant. MITIGATION: This risk will be mitigated by initiating design, development, and construction of a first prototype space nuclear fission power plant that would be developed for limited-time operation in space. This prototype will provide lessons learned and proof of concept demonstrations to reduce technical uncertainties.

Human Systems Research and Technology



President's FY 2006 Budget Request (Dollars in Millions)

Human Systems Research and Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	985.6	1,003.9	806.5	796.7	812.4	818.5	815.8
Changes from FY 2005 Request	19.0	-26.3	-123.3	-122.4	-116.8	-115.4	

Overview: *What* NASA Accomplishes through the Human Systems Research and Technology Theme

The Human Systems Research and Technology (HSR&T) Theme represents a new focus for the programs and projects of the former Biological and Physical Research Enterprise (BPRE). By transforming the BPRE organization and adopting a requirements-based philosophy in the redirection of its programs NASA will be able to reprioritize ISS research and realize efficiencies in its investments by focusing them on technologies applicable to human exploration of the solar system. Such efficiencies allow NASA to adjust the investment profile for HSR&T and still return significant benefits to the space program and the Nation.

Programs in this Theme will advance the technologies directly supporting long-term human habitation, survival, and performance. As a result NASA will be sure that future systems are designed to most effectively and efficiently utilize the human system. HSR&T programs assure the timely development, documentation, and communication of key research results that will improve medical care and human health maintenance in future space exploration missions. These results will ensure that decisions concerning the design and operation of future human systems are informed by the best available knowledge. The Theme is comprised of three programs: the Life Support and Habitation program, the Human Health and Performance program, and the Human Systems Integration program.

Theme: Human Systems Research and Technology

Relevance: *Why* NASA conducts Human Systems Research and Technology work

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

HSR&T is a requirements-driven program that strives to enable the Vision for Space Exploration by developing advanced capabilities, supporting technologies, and foundational research that enables affordable and sustainable human exploration missions. HSR&T will deliver solutions for crew health, safety, and productivity in deep space that reduces mission risk and cost.

Relevance to the NASA mission:

HSR&T supports NASA's mission to explore the universe by reducing long-duration mission cost and risk in the areas of crew health and performance, life support and habitation, and improved extra vehhicular activities. HSR&T will carry out critical research using the International Space Station to enable long-duration human space missions.

Relevance to education and public benefits:

HSR&T will promote the technical education of future scientists, engineers, and health care professionals by providing direct opportunity to participate in space exploration projects. The development of advanced technologies for autonomous medical care, closed-loop life support, and resource recycling will provide benefits to the quality of life across the world.

Performance

Major Activities Planned for FY 2006:

- Early completion of the renal stone countermeasure development project.
- Begin testing of bone and cardiovascular countermeasures in space.
- Complete study and deliver report on lunar radiation protection requirements.
- Complete the technology trade studies for both the in-space and surface extra-vehicular activity (EVA) suits.
- Revise and update standards for human cognition, human performance, assessment, and human interfaces.

Major Recent Accomplishments:

- HSR&T has shifted from a discipline-focused Theme to a requirements-driven product-delivery Theme. A zero-based program review was initiated in to identify gaps in research required to support ESMD.

Theme: Human Systems Research and Technology

Human Systems Research and Technology Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

8. Focus research and use of the ISS on supporting space exploration goals, with emphasis on understanding how the space environment affects human health and capabilities, and developing countermeasures.

8.5 By 2008, develop and test the following candidate countermeasures to ensure the health of humans traveling in space: bisphosphonates, potassium citrate, and mitodrine.

6HSRT9 Complete renal stone countermeasure development.

6HSRT10 Start testing of bone & cardiovascular countermeasures in space.

8.6 By 2008, reduce the uncertainties in estimating radiation risks by one-half.

6HSRT11 Deliver report from National Council on Radiation Protection and Measurements on lunar radiation protection requirements.

8.7 By 2010, identify & test technologies to reduce total mass requirements for life support by two thirds using current ISS mass requirement baseline. By 2010, identify and test technologies to reduce total mass requirements for life support by two thirds using current ISS mass requirement baseline.

6HSRT13 Start validation testing of a spacecraft water purification system called the Vapor Phase Catalytic Ammonia Removal Unit.

6HSRT14 Define requirements for the Condensing Heat Exchanger Flight experiment focused on improving space condenser reliability.

6HSRT15 Complete and deliver for launch the ISS Fluids Integrated Rack.

6HSRT16 Complete and deliver for launch experiments to explore new lightweight heat rejection technologies.

6HSRT17 Start technology testing and assessment of the Solid Waste Compaction processor.

6HSRT18 Conduct next generation lithium hydroxide (LiOH) packaging tests to improve carbon dioxide removal efficiency.

6HSRT19 Conduct ground testing of the Sabatier unit to demonstrate reliability in recovering oxygen and water from carbon dioxide.

8.8 By 2008, develop a predictive model and prototype systems to double improvements in radiation shielding efficiency.

6HSRT20 Complete physics database for shielding in region above 2GeV per nucleon.

11. Develop and demonstrate power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations.

11.1 By 2010, develop new, reliable spacecraft technologies to detect fire and monitor air and water for contamination.

6HSRT3 Demonstrate the ability of the advanced spacecraft air monitoring system to detect 90% of the high-priority air contaminants in ground testing.

6HSRT4 Demonstrate the ability of the hand-held water monitoring system to detect spacecraft water biocides and high-priority metal contaminants in ground testing.

6HSRT5 Support development of a new generation of reliable spacecraft smoke detectors by finishing measurements of ISS background particulates using the DAFT experiment and delivering for launch the Smoke and Aerosol Measurement Experiment (SAME).

11.2 By 2010, develop methods to quantify material flammability and fire signatures in reduced gravity.

6HSRT6 Complete and deliver for launch the ISS Combustion Integrated Rack (CIR).

6HSRT7 Complete and deliver for launch the Droplet Flame Extinguishment in Microgravity Experiment aimed at quantifying fire suppressant effectiveness.

6HSRT8 Develop a revised space materials flammability characterization test method and update NASA-STD-6001 accordingly.

11.9 By 2010, develop and test Extravehicular Activity (EVA) space and surface suit technologies for use on crewed exploration missions.

6HSRT1 Complete the technology trade studies for both the in-space and surface EVA suits.

6HSRT2 Complete the system requirements review for both the in-space and surface exploration EVA suits.

Efficiency Measures

6HSRT21 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6HSRT22 Increase annually, the percentage of grants awarded on a competitive basis.

6HSRT23 Peer review and competitively award at least 80%, by budget, of research projects.

6HSRT24 Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days.

Program Management

The Theme Director is Dr. Eugene Trinh.

Quality

Independent Reviews:

- External non-advocate panels conducting Theme-wide Zero-Based Review.
- Set priorities for ISS research by the National Academy of Science.

Program Assessment Rating Tool (PART):

The Office of Management and Budget has not yet conducted a PART review of the Human Systems Research and Technology Theme.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Human Systems Research and Technology	**985.6**	**1,003.9**	**-197.4**	**806.5**	
Research Partnerships and Flight Support	263.4				
Physical Sciences Research	357.3				
Biological Sciences Research	364.9				
Life Support and Habitation		332.5	-31.6	300.9	
Human Health and Performance		422.5	-123.7	298.8	
Human Systems Integration		248.9	-42.1	206.8	

Theme: Human Systems Research and Technology
Program: Life Support and Habitation

President's FY 2006 Budget Request

(Dollars in Millions)

Life Support and Habitation	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		332.5	300.9	282.7	280.8	266.7	254.8

Overview

Life Support and Habitation focuses on enabling human exploration beyond low Earth orbit by:

A) Closing the loop for air, water, and food to make exploration missions feasible and to reduce mission logistics and cost. The emphasis will be on introducing new technologies, ensuring the extension of life cycles, introducing new maintainability capabilities, and validating low- and reduced-gravity critical processes.

B) Developing a robust surface and space extra vehicular activity (EVA) suit and associated technologies required for missions beyond low Earth orbit. New suit designs and prototypes will be validated in relevant environments and provided to the Constellation Systems Theme.

C) Achieving a new level of reliable and maintainable life support and environmental monitoring and control systems. Emphasis will be to enhance reliability, maintainability, portability, and system distribution.

D) Developing novel technologies to enhance exploration crew autonomy through the capabilities to manufacture replacement tools, mechanical parts, or to produce resources for human life support using in-space or in-situ planetary resources.

This program supports Objectives 11.1, 11.2, and 11.3. For more information see:
http://exploration.nasa.gov/programs/human.html.

Life Support and Habitation focuses on enabling human exploration by developing next generation extra-vehicular activity technologies for in-space and surface exploration suites.

Plans For FY 2006

Complete the technology trade studies for both the in-space and surface EVA suits.

Complete the system requirements review for both the in-space and surface exploration EVA suits.

Demonstrate the ability of the advanced spacecraft air monitoring system to detect 90 percent of the high-priority air contaminants in ground testing.

Demonstrate the ability of the hand-held water monitoring system to detect spacecraft water biocides and high-priority metal contaminants in ground testing.

Complete and deliver for launch the ISS Combustion Integrated Rack.

Complete and deliver for launch the Droplet Flame Extinguishment in Microgravity (DAFT) Experiment aimed at quantifying fire suppressant effectiveness.

Develop a revised space material flammability characterization test method and update NASA-STD-6001 accordingly.

Support development of a new generation of reliable spacecraft smoke detectors by finishing measurements of ISS background particulates using the DAFT experiment and delivering for launch the Smoke and Aerosol Measurement Experiment.

Start validation testing of a spacecraft water purification system called the Vapor Phase Catalytic Ammonia Removal Unit.

Define requirements for the Condensing Heat Exchanger flight focused on improving space condenser reliability.

Complete and deliver for launch the ISS Fluids Integrated Rack.

Complete and deliver for launch experiments to explore new lightweight heat rejection technologies.

Changes From FY 2005

- The program has transformed from a discipline focus to a requirements-driven product-delivery focus. A zero-based program review was initiated in to identify gaps in research required to support ESMD.
- This transformation will create efficiencies in HSR&T investments by focusing them on technologies applicable to human exploration of the solar system.

Program Management

This program is managed at NASA Headquarters and supported by technical and project management at the NASA Centers.

Theme: Human Systems Research and Technology
Program: Life Support and Habitation

Technical Description

The objective of the Life Support and Habitation program is to provide cost-effective, requirement-driven technology solutions that reduce risk, enable sustainable exploration missions, and enhance crew safety. Key areas of focus are the development of extra vehicular activity technologies for in-space and surface exploration suits; long-term sustainable spacecraft life support systems; monitoring and maintenance of crew cabin environmental conditions; contingency response capabilities (fire protection, detection, and suppression; in-situ resource utilization for fabrication and repair) and in-situ life support processes.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Advanced Life Support								Supports development of advanced technologies to close the life support system loop to enable long-duration exploration missions.	Tech Form Dev Ops Res	Sep-04	Dec-20
Advanced EVA Systems								Develops next-generation EVA technologies for in-space and surface exploration suits.	Tech Form Dev Ops Res	Sep-03	Dec-20
Advanced Environmental Monitoring and Control								Supports development of new spacecraft technologies to reliably monitor air, water, and surfaces for contamination.	Tech Form Dev Ops Res	Sep-03	Dec-20
Applied Exploration Research								Conducts advanced concepts exploration research that provides a foundation for new exploration technologies.	Tech Form Dev Ops Res	Sep-03	Dec-20
In-situ Life Support Processes								Develops advanced technologies that reduce mission resource requirements by obtaining life support consumables locally.	Tech Form Dev Ops Res	Sep-03	Dec-20
Contingency Response Technology								Enhances fire safety by developing new technologies for prevention, detection, and suppression. Develops advanced fabrication, repair, and habitat technologies that reduce mission risk.	Tech Form Dev Ops Res	Sep-03	Dec-20

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

Strategy For Major Planned Acquisitions

- FY 2005 - Water recovery and purification Broad Agency Announcement in cooperation with the Office of Naval Research.
- FY 2005 - Spiral 1 Technology Infusion Braod Agency Announcement for HSR&T technologies specific to life support, habitation, and EVA technologies.

Key Participants

- NASA Centers play a role in Project Management Teams, Research Teams, and Integrated Discipline Teams, and Intramural Projects. Industry and academia participate in extramural projects, teaming arrangements with NASA Centers and other government agencies through interagency agreements.

Risk Management

- RISK: Key risks include the failure of technologies to mature in key technology areas for infusion into Constellation Systems programs. MITIGATION: The mitigation strategy is to mature several competing technologies (i.e. several different CO2 removal systems) to ensure the capability ia available for the CEV and subsequent programs.
- RISK: An additional key risk includes research delays associated with Shuttle return to flight and payload upmass/crew time shortages. MITIGATION: The mitigation strategy is to have a strong ground-based research program to complement the flight program.

Theme: Human Systems Research and Technology
Program: Human Health and Performance

President's FY 2006 Budget Request

(Dollars in Millions)

Human Health and Performance	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		422.5	298.8	303.0	319.6	327.7	339.9

Overview

Human Health and Performance delivers research and technology knowledge and tools in four areas of life sciences that will enable human space exploration:

A) Human health countermeasures, including exercise devices and prescriptions, recommendations for artificial gravity use, understanding and requirements for use of drugs and nutrition, as well as countermeasures for individual body systems degradation due to exposure to the space environment.

B) Tools and techniques to improve medical care delivery to space exploration crews. These include preventive medicine strategies, tools and advanced instrumentation for autonomous medical care, monitoring, diagnosis, and treatment, as well as a medical informatics database.

C) Biomedical knowledge and tools to improve estimation of space radiation health risks to human crews of acute and life-long carcinogenesis, brain and other tissue non-cancer damage, as well as heredity and fertility changes, and to develop and test effectiveness of existing and novel radiation shielding materials.

D) New information in exploration biology, that will identify and define the scope of problems which will face future human space explorers during long periods of exposure to space.

This program supports Objectives 8.5, 8.6, 8.7, and 8.8. For more information see: http://exploration.nasa.gov/programs/human.html.

Crew member exercising on the treadmill located in the Zvezda Service Module of the International Space Station. Research investigations are being performed on ISS crewmembers to address the risks associated with space flight, to better understand how the various human physiological systems are responding to space flight, and to develop countermeasures (e.g., exercise, pharmacology) to slow or prevent any deleterious changes from occurring.

Plans For FY 2006

Early completion of the renal stone countermeasure development project.

Begin testing of bone and cardiovascular countermeasures in space.

Complete study and deliver report on lunar radiation requirements.

Complete physics database for shielding in region above 2 GeV per nucleon.

Begin collecting medical data on "space norms" - the "normal" biological and physical medical levels in space.

Begin phase II of the artificial gravity project.

Changes From FY 2005

- The program has shifted from a discipline focus to a requirements-driven product-delivery focus. A zero-based program review was initiated in to identify gaps in research required to support ESMD.
- This transformation will create efficiencies in HSR&T investments by focusing them on technologies applicable to human exploration of the solar system.

Program Management

This program is managed at NASA Headquarters and supported by technical and project management at the NASA Centers.

Technical Description

The program performs systematic studies of human physiological, behavioral, and chemical changes induced by space flight. The program consists of four program elements: Human Health Countermeasures, Exploration Biology, Autonomous Medical Care, and Space Radiation. NASA is accumulating long-term data on adaptation to the space environment. The Human Research Facility is hardware that provides the major on-orbit capability to perform this research, including high-resolution imaging for diagnostics and research applications for human organs. NASA studies areas of concern to human well-being and performance, such as renal stone risk, bone loss, and the effects of ionizing radiation to ensure human safety during space exploration is maximized.

Theme: Human Systems Research and Technology
Program: Human Health and Performance

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Human Health Countermeasures								Identify countermeasure techniques to protect astronauts from the harmful effects of the space environment.	Tech Form Dev Ops Res	Oct-04	Dec-10
Exploration Biology								Conduct studies on the impact of reduced gravity on human performance and formulate predictive models of human responses to microgravity.	Tech Form Dev Ops Res	Oct-04	Dec-10
Autonomous Medical Care								Identify techniques to improve astronaut medical care and crew health optimization	Tech Form Dev Ops Res	Oct-04	Dec-10
Space Radiation								Evaluates the radiation risks to astronauts engaged in exploration missions.	Tech Form Dev Ops Res	Oct-04	Dec-10

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

Strategy For Major Planned Acquisitions

- FY 2005 - Broad Agency Announcement to develop human health countermeasures.
- FY 2006 - Broad Agency Announcement for ground- and flight-based research for health in space supporting autonomous medical care and countermeasures.
- FY 2006 - Broad Agency Announcement for ground-based studies for radiation biology and radiation shielding.

Key Participants

- NASA Headquarters, NASA Centers, the Space Biomedical Research Institute, universities, the life sciences research community, industry, and other government agencies.

Risk Management

- RISK: Risks include limited up-mass to ISS and a limited number of test subjects with exposure to long-duration microgravity. MITIGATION: Develop innovative techniques to process medical samples on orbit rather than bringing back to Earth for analysis; increase modeling and data analysis capability to leverage limited data points; focus program on "must do" research to enable safe human exploration of space.

Theme: Human Systems Research and Technology
Program: Human Systems Integration

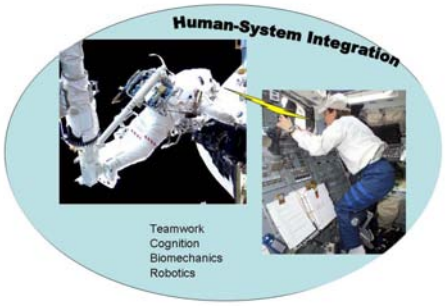
President's FY 2006 Budget Request

(Dollars in Millions)

Human Systems Integration	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD		248.9	206.8	211.0	212.0	224.2	221.0

Overview

Human Systems Integration research and technology development is driven by Agency needs for crew health; design of human spacecraft, space suits, and habitats; efficient crew operations; medical operations; and technology development to enable safe and productive human space exploration.



Humans inside and outside a spacecraft use robotic arms to explore our universe. Safety and mission success depend upon teamwork. Teamwork relies on everyone being cognitively and physically ready to perform.

Behavioral health and performance research contributes to medical standards, guidelines, and requirements and produces design tools and diagnostic measures for the Chief Health and Medical Officer, flight surgeons, and astronauts. The technical areas supported by this program include sleep and chronobiology, neurobehavioral performance, cognitive dysfunction, and psychosocial adaptation.

Space human factors engineering research produces engineering standards, guidelines, requirements, design tools, training systems and evaluation approaches to support the astronauts, design engineers, and missions operations. The scope of this research includes physical, cognitive, and team performance factors.

The program is currently funding research that addresses identified needs in physical and cognitive performance factors, psychosocial adaptation, neurobehavioral adaptation, and sleep and circadian rhythms. This research is important because the human subsystem has physical and cognitive interface requirements that must be addressed in spacecraft design and operation. Team performance factors (human-automation and human-human coordinated activities) are vital to successful mission performance. Missions must be designed to be accomplished by available combinations of crew and automation.

This program supports Objectives 11.1 and 11.9.
http://exploration.nasa.gov/programs/human.html

Theme: Human Systems Research and Technology
Program: Human Systems Integration

Plans For FY 2006

Revise and update standards for human cognition, human performance, assessment, and human interfaces.

Perform research for interventions for dysfunctional neurobehavioral performance.

Initiate research in training for multi agent team effectiveness.

Initiate research in unobtrusive, objective assessment tools for stress reactions.

Perform research in identifying effective communication and interpersonal styles for small teams.

Perform research in the safety of using blue light as a tool in resetting the body's internal clock.

Implement plans resulting from the "Human Cognition in Space Workshop: Metrics and Models" (October 2004) and the "Human-Systems Integration Stakeholder Workshop" (January 2005).

Changes From FY 2005

- The program has transformed from a discipline focus to a requirements-driven product-delivery focus. A zero-based program review was initiated in to identify gaps in research required to support ESMD.
- This transformation will create efficiencies in HSR&T investments by focusing them on technologies applicable to human exploration of the solar system.

Program Management

This program is managed by NASA headquarters with significant participation from NASA Centers for technical and project support.

Technical Description

The program supports research on the body's internal clock in order to help astronauts adjust to the Martian day and to shift sleep schedules during flight operations in Earth orbit or extended duration missions. The program is revising NASA-STD-3000, Human-System Integration Standards, to reflect lessons learned from the Space Shuttle and ISS missions. The Multi User Systems and Support project enables the utilization of the ISS by: preparing various medical and engineering research payload elements for integration with ISS facilities; planning payload operations for upcoming ISS increments, insuring data distribution to U.S. and International Partners; and is an important element of ESMD efforts to develop critical technologies and human health data for future exploration missions.

Theme: Human Systems Research and Technology
Program: Human Systems Integration

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Behavioral Health and Performance								Research in this area contributes to medical standards, guidelines, and requirements for human space flight operations.	Tech Form Dev Ops Res	Oct-04	Dec-20
Space Human Factors Engineering								Research in this area identifies physical, cognitive, and team performance factors that will lead to training and operating procedures that best prepare astronauts for mission operations.	Tech Form Dev Ops Res	Oct-04	Dec-20
Multi-User System and Support								Multi-User System and Support projects enable effective ISS operations and utilization.	Tech Form Dev Ops Res	Oct-03	Feb-16

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

Strategy For Major Planned Acquisitions

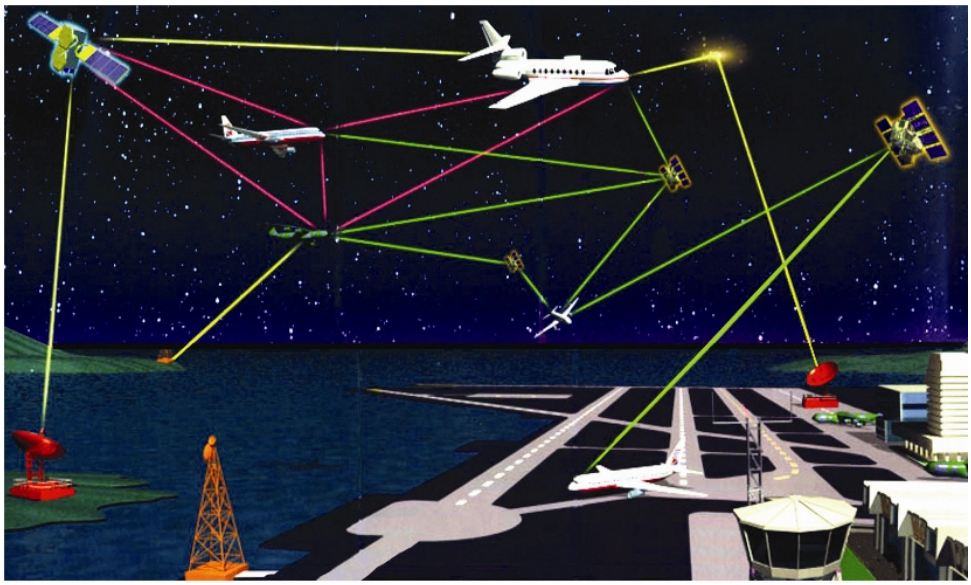
- Major planned acquisitions will be aligned with ESMD intramural and extramural solicitations.

Key Participants

- Key stakeholders are represented on the Human Systems Integration Steering Group including: the Astronaut Office, Office of the Chief Health and Medical Officer, and Space Operations Mission Directorate Medical Operations.

Risk Management

- RISK: Risks to the successful integration of humans and engineered systems come from inappropriate task design and roles assigned to crew members; poor human-software and human-hardware interface design; and, inappropriate uses of automation and robotics. MITIGATION: HSI mitigates these risks by soliciting research and technology development to understand the underlying causes of human performance failures and to develop measurement and detection techniques and to develop and validate countermeasures.
- RISK: Additional risks to successful human operations in space include poor team interaction; a lack of sleep and circadian rhythm shifts; and, errors in cognitive function. MITIGATION: HSI mitigates these risks by soliciting research and technology development addressing the underlying causes of human performance failures.



The Aeronautics Research Mission Directorate is developing the technologies to provide precise knowledge of vehicles and weather conditions, optimized interaction between humans and automated systems, and advanced vehicle technologies that will enable a safer, more secure, efficient, and environmentally friendly air transportation system.

Theme

Aeronautics Technology

AERONAUTICS RESEARCH

Purpose

Over the last century, aviation has evolved into an integral part of our economy, a cornerstone of national defense, and an essential component of our every-day life. Aviation generates more than $1 trillion of economic activity in the United States every year. Americans rely on aviation not just for transportation but for recreation as well. Its growth has been fueled by the ability of aviation to offer very safe, affordable, fast, predictable movement of goods and people. Just as the Nation has become more dependent on faster and more efficient air travel, important challenges have emerged. Those challenges include the reduction in the fatal accident rate; the need to ensure the safety and security of air travel after the September 11 attacks; the reduction of air and noise pollution, which impose restrictions on the number and type of aircraft operating in certain areas; and improvement of efficiency/capacity of the air traffic and airport systems.

The Aeronautics Research Mission Directorate (ARMD) supports the NASA mission to understand and protect the home planet. NASA's investment in aeronautics research plays a key role in the technology developments that are necessary to solve the challenges faced by the aeronautics community and thereby creates a safer, more secure, environmentally friendly, and efficient national aviation system as well as supporting revolutionary science. Research areas include advanced propulsion technologies using hydrogen fuel, airframe and propulsion technologies for noise reduction, lightweight high-strength structures, modern decision support tools, revolutionary display and control systems, adverse weather countermeasures, adaptive controls, and advanced vehicle designs. In collaboration with the Federal Aviation Administration (FAA), research is conducted in air traffic management technologies for new automation tools and concepts operations. Similarly research is conducted in collaboration with the Department of Homeland Security to improve the security of the National Airspace System (NAS). For more information see: http://www.aero-space.nasa.gov/

FY 2004 Accomplishments

During FY 2004, the Aeronautics Research Mission Directorate made substantial progress in developing aeronautics technologies that, when implemented, will support a 21st century air transportation system that is safer, more efficient, environmentally friendly, flexible, and able to meet the increasing demands of the Nation.

World Speed Record. The Hyper X (X-43A) scramjet flight test vehicle again set a new aeronautical speed record for an aircraft powered by an airbreathing engine when it flew at nearly Mach 10 on November 16, 2004. This high-risk flight was a follow-on to the March 2004 flight, that had set the previous speed record of Mach 6.8. An important product of flight research was its successful collection of never before obtained data on actual scramjet operation. This data will be used to validate scramjet ground predictions and modeling codes.

Detection of rogue aircraft. A prototype of the Rogue Evaluation And Coordination Tool (REACT) was evaluated using a live traffic feed over eight hours, for both the Fort Worth, Texas, and Washington, D.C., air traffic control centers. REACT demonstrated the ability to detect aircraft that are deviating from their expected flight paths using four detection algorithms. It also predicted the length of time before the incursions entered into restricted airspace. These capabilities will enhance public safety by mitigating the potential for catastrophic harm that might otherwise result from a rogue aircraft.

Aviation Synthetic Vision. Complementary simulation and flight-test evaluations of low-cost forward-fit and retrofit Synthetic Vision System (SVS) technologies were performed for general aviation (GA) aircraft. The new system will improve situational awareness by giving pilots “enhanced vision,” sensor-based information about terrain and man-made features when visibility is obscured. The Synthetic Vision System creates an artificial, computer-generated view, based on a detailed terrain database. Although the pilot may not be able to see the ground through the fog, a computer screen presents the landing site accurately based on map and terrain information. Results from this effort demonstrated the efficacy of SVS displays to eliminate a primary cause of general aviation accidents (controlled flight into terrain) and greatly improve pilot situational awareness.

Reducing sonic booms. An aircraft traveling through the atmosphere continuously produces air pressure waves similar to waves created by the bow of a ship. When the aircraft exceeds the speed of sound, the pressure waves merge to form shock waves, which are heard as a sonic boom when they reach the ground. The annoyance and damage generated by these sonic booms has been one of the limiting factors for routine supersonic flight over land. In a joint program conducted by NASA, Defense Advanced Research Projects Agency (DARPA), and the Northrop Grumman Corporation, the forebody of an F-5 fighter was modified to test the theory that by changing an aircraft’s shape, the shape of the sonic boom can be adjusted to reduce its impact on the public. This technology may enable a generation of supersonic aircraft that are far less disturbing to the public.

Advanced Air Transportation Technologies project Completion. The Advanced Air Transportation Technologies (AATT) project was successfully completed. The project developed Air Traffic Management decision-making technologies and procedures that enabled greater flexibility and efficiencies of the National Airspace System (NAS) dynamic. Over a five-year time span, AATT project developed, demonstrated, and transitioned several active decision support tools to the FAA, which will enable improvements in NAS throughput, user flexibility, and predictability while maintaining safety. This includes the Multi-Center Traffic Management Advisor, which allows controllers to manage arrival flows across multiple routes and arrival points more efficiently. An analysis of the integrated benefits shows the project has achieved its goals of enabling an increase in terminal throughput by 35 percent and an increase in en route throughput by 20 percent.

Mission Directorate: Aeronautics Research

Theme Distribution

Budget Authority ($ in millions)	FY 2004	FY 2005	FY 2006
Aeronautics Technology	1056.8	906.2	852.4
Total	1056.8	906.2	852.4

Note: For all formats, the FY 2004 column reflects the FY 2004 Congressional Operating Plan, dated 9/28/2004. The FY 2005 column reflects the FY 2005 Congressional Operating Plan, dated 12/23/2004. The FY 2006 column represents the FY 2006 President's Budget Submit.

Aeronautics Research

The Aeronautics Research Mission Directorate (ARMD) plays a key role in creating a safer, more secure, environmentally friendly, and efficient air transportation system, and developing new uses for science or commercial missions. The ARMD serves the Nation through the development of technologies to improve aircraft and air system safety, security, and performance; reduce aircraft noise and emissions; and increase the capacity and efficiency of the National Airspace System. ARMD leads U.S. aeronautics by enabling technologies, beyond the immediate horizon of its customers and industrial partners. ARMD also conducts research that will enable uncrewed aerial vehicles (UAVs) to be used for revolutionary Earth and space science missions.

ARMD's research is done in partnership with other government agencies, academia, and industry to ensure effective development and transfer of new technologies. As part of a national effort, NASA and FAA Joint Planning and Development Office have developed an integrated plan (blueprint) for the Next Generation Air Transportation System. This blueprint will lead to the transformation of America's air transportation network by 2025. ARMD develops and transfers technologies that create a safer, more secure, environmentally friendly, and efficient air transportation system.

ARMD consists of three integrated programs: The Aviation Safety and Security program mitigates actions that would cause damage or loss of life; the Airspace Systems program enables revolutionary improvements to the National Airspace System; and the Vehicle Systems program demonstrates technologies to reduce aircraft noise, enable a zero emissions aircraft, and develop UAVs for Earth and space science missions. Highlights for FY 2006 include:

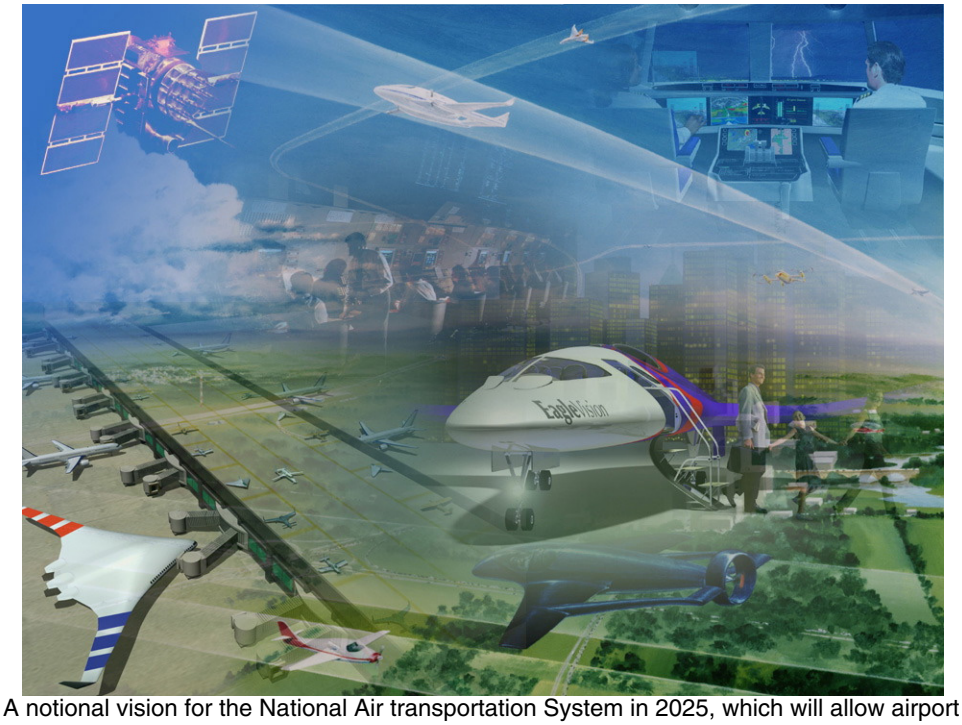
- Development of a modeling and simulation capability for National Airspace Systems.
- Development of strategic management tools for National Airspace Systems.
- Development of wake vortex operation procedures and standards to safely increase the terminal area capacity and allow reduced separation standards for wake vortex avoidance considerations.
- Demonstration of prototype Distributed National Archives for Flight Operations Quality Assurance (FOQA) and Aviation Safety Action Program data with the FAA.

Overall Budget

The FY 2006 request is $852.4 million, a 6 percent decrease from the FY 2005 budget:

- $192.9 million for Aviation Safety and Security projects to decrease accident and fatality rates.
- $200.3 million for Airspace Systems projects to provide technologies that can dramatically increase the capacity and mobility of the Nation's air transportation system.
- $459.1 million for Vehicle Systems projects to demonstrate technologies that will reduce aircraft noise and emissions, and to develop uncrewed aerial vehicles for Earth and space science missions.

Aeronautics Technology



A notional vision for the National Air transportation System in 2025, which will allow airport and airspace capacity to be more responsive, adaptable, and dynamic.

President's FY 2006 Budget Request

(Dollars in Millions)

Aeronautics Technology	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	1,056.8	906.2	852.3	727.6	730.7	727.5	717.6
Changes from FY 2005 Request	22.5	-13.0	-104.4	-210.2	-195.0	-214.4	

Overview: *What* NASA Accomplishes through the Aeronautics Technology Theme

The Aeronautics Technology (AT) serves the Nation through the development of technologies to improve aircraft and air system safety, security and performance; reduce aircraft noise and emissions; and increase the capacity of the National Airspace System (NAS). AT leads U.S. Aeronautics by developing revolutionary technologies, beyond the immediate horizon of our customers and industrial partners. The research is considered "barrier breaking," developing relevant demonstrations of technologies that show feasibility to remove the first-order barriers. AT also conducts research that enables revolutionary aerial vehicles to be used for science missions.

AT's research is done in partnership with other agencies, academia, and industry to ensure effective development and transfer of new technologies. As part of a national effort, NASA has supported the Joint Planning and Development Office to develop an integrated plan (blueprint) for the Next Generation Air Transportation System. Using this blueprint, AT conducts the long-range research and develops/transfers technologies that will enable the transformed system by 2025.

AT consists of three integrated programs: Aviation Safety & Security (technology to mitigate actions that would cause damage or loss of life); Airspace Systems (enables revolutionary improvements to the NAS); and Vehicle Systems (enables environmentally friendly aviation systems and the use of revolutionary uncrewed aerial vehicles for science missions.)

Theme: Aeronautics Technology

Relevance: *Why* NASA conducts Aeronautics Technology work

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

Over the last century, aviation has evolved into an integral part of our economy, a cornerstone of national defense, and an essential component of our every-day life. Aviation generates more than $1 trillion of economic activity in the United States every year. Americans rely on aviation for transportation and recreation. Its growth has been fueled by the ability of aviation to offer very safe, affordable, fast, predictable movement of goods and people. Our Nation has become more dependent on moving people and goods faster and more efficiently via air. NASA's investment in the AT theme enables technologies that are necessary to create a safer, more secure, environmentally friendly, and efficient national aviation system as well as supporting revolutionary science missions both in our atmosphere and in atmospheres of other worlds.

Relevance to the NASA mission:

AT supports the NASA mission to understand and protect the home planet. AT has the primary responsibility of providing advanced aeronautical technologies to meet the challenges of next-generation systems in aviation, for civilian and scientific purposes.

Relevance to education and public benefits:

The technologies that are being developed by AT will enable a future where individuals have on-demand, as well as scheduled air mobility allowing travel where we want, when we want, faster, safer, and without delays to both rural and urban areas. This is a future where the noise associated with aviation operations will be confined within the airport perimeter, where aircraft emissions will be below objectionable limits, where avoidable aircraft accidents will be a thing of the past, and where the security of commercial aircraft operations is not a concern.

Performance

Major Activities Planned for FY 2006:

- Successfully complete the SATS integrated technology demonstration and assessment
- Develop strategic management tools for Natonal Airspace Systems.
- Develop wake-vortex operation procedures/standards.
- Demonstrate prototype Distributed National Archives for Flight Operations Quality Assurance and Aviation Safety Action Program data with participation of multiple airlines, vendors, and the FAA.
- Downselect appropriate next-generation noise reduction technologies for validation.

Major Recent Accomplishments:

- NASA's successful X-43A flight demonstrated that an air-breathing scramjet engine can fly at nearly 10 times the speed of sound. A world speed record was also set on this flight.
- NASA demonstrated that by altering the contours of a supersonic aircraft, the shockwave and its accompanying sonic boom can be shaped to greatly reduce the intensity of a sonic boom on the ground.
- NASA/FAA demonstrated the ability of rogue software to detect aircraft that are deviating from their expected flight paths and predict entry into restricted airspace.
- Successfully completed the Advanced Air Transportation Technologies project that developed ATM decision-making technologies & procedures which enabled greater flexibility and efficiencies of the NAS.

Theme: Aeronautics Technology

Aeronautics Technology Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

12. Provide advanced aeronautical technologies to meet the challenges of next generation systems in aviation, for civilian and scientific purposes, in our atmosphere and in atmospheres of other worlds.

12.2 Develop and validate technologies (by 2009) that would enable a 35 percent reduction in the vulnerabilities of the National Airspace System (as compared to the 2003 air transportation system).

6AT1 Security system concepts defined that provide reduced vulnerability from intentional attacks, including protected asset flight system concept of operation, evaluation of information distribution vulnerabilities, evaluation of strategy for aircraft damage emulation, definition of fuel flammability needs, identification of key environmental background for on-board sensing, and requirements for processing of large security related databases. (AvSSP)

6AT2 Complete the assessment of the Security Program technology portfolio with regard to risks, costs, and benefits and project the impact of the technologies on reducing the vulnerability of the air transportation system. (AvSSP)

12.3 Develop and validate technologies that would enable a 10-decibel reduction in aviation noise (from the level of 1997 subsonic aircraft) by 2009.

6AT8 Downselect components for noise reduction that will be validated in a relevant environment to verify their potential to achieve 4dB noise reduction (VSP)

12.4 By 2010, flight demonstrate an aircraft that produces no CO2 or NOx to reduce smog and lower atmospheric ozone.

6AT11 Complete trade study of unconventional propulsion concepts for a zero-emissions vehicle (VSP)

12.6 Develop and validate technologies (by 2009) that would enable a doubling of the capacity of the National Airspace Systems (from the 1997 NASA utilization).

6AT5 Conduct successful operational demonstration of multifacility time-based metering in complex airspace (ASP)

6AT6 Complete development of system-wide evaluation and planning tool (ASP)

6AT7 Successfully complete the SATS integrated technology demonstration and final assessment (ASP)

12.7 Develop and validate technologies (by 2010) that would enable a 70 percent reduction in the aircraft fatal accident rate (from the average of accident statistics for US Civil Aviation for the period 1991 - 1996).

6AT3 Evaluate and prioritize NASA's aviation safety technology portfolio to determine the impact on the National Airspace System. (AvSSP)

6AT4 In partnership with the FAA, the Commercial Aviation Safety Team (CAST), and the aviation community, provide an initial demonstration of a voluntary aviation safety information sharing process. (AvSSP)

12.8 Develop and validate technologies that would increase the capabilities of uninhabited aerial vehicles in terms of duration, altitude, autonomy, and payload.

6AT10 Demonstrate a HALE ROA reconfigurable flight control architecture (VSP)

12.10 By 2008, develop and demonstrate technologies required for routine Unmanned Aerial Vehicle operations in the National Airspace System above 18,000 feet for High-Altitude, Long-Endurance (HALE) UAVs.

6AT9 Propose policy changes to the FAA that would permit routine operation of HALE ROA above 40,000 feet (VSP)

Efficiency Measures

6AT12 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6AT13 Increase the annual percentage of research funding subject to external peer review prior to award.

Program Management

Dr. J. Victor Lebacqz is the Associate Administrator of ARMD. The Directorate Program Management Council is the governing authority.

Quality

Independent Reviews:

- ARMD conducts a monthly review of the progress and performance of each program. In addition, ARMD conducts an in depth review of each program on a quarterly basis. The ARMD also reports the status and accomplishments of each of its programs to the Agency Program Management Council on a quarterly basis. There are no program performance issues.
- During CY 2003, the National Research Council conducted a detailed technical and quality assessment of the Aeronautics Research Mission Directorate. The assessment concluded that the quality of the programs is very good and provided some recommendations for improvement. NASA is working on the implementaion of these recommendations. The NRC will be conducting these reviews every three years.
- The Aeronautics Research Advisory Committee assesses the relevance of the ARMD research programs on a semi-annual basis. The reviews have reinforced the comments from the NRC that ARMD is conducting quality and relevant research. Beginning in 2005, the committee will also be assessing the effectiveness of the ARMD technology transfer activities.

Program Assessment Rating Tool (PART):

The Aeronautics Technology (AT) Theme received a PART rating of "moderately effective." The assessment concluded that AT has a clear purpose and was developing the technologies required to address the challenges facing the civilian aviation community to the point where they can be transitioned to a customer in government or industry. Furthermore AT had established challenging long term and annual goals that were measurable and verifiable, and directly supported its strategic objectives. The assessment also determined that there was an effective use of independent evaluations and other management processes to both accurately monitor progress of the individual research tasks and integrate these results into an accurate assessment of overall technical progress. Specifically, the NRC provided a set of recommendations that AT is currently implementing.

The overall assessment was that AT's performance compared favorably to similar programs in both the private sector and other government agencies. It also found that AT could improve its performance by increasing the use of a peer review process in the selection of research tasks, implementing processes to improve and track the efficiencies and cost effectiveness of the AT portfolio, and to restructure the program to better focus on projects that have a federal role.

NASA is establishing procedures to increase the use of competition based selection of its research projects and activities and to monitor and improve the efficiency of the AT portfolio. In addition, as reflected in this budget request, AT has also transformed its program to focus on projects that demonstrate breakthrough technologies/capabilities. The key aspects of this action was to change from a philosophy of broad technology based research and technology to a few focused projects for development and demonstrations of barrier breaking technologies, reducing the number of independent research activities to a selected number of high-risk, high-payoff demonstrations, and the elimination of incremental aeronautics technology projects.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Aeronautics Technology	**1,056.8**	**906.2**	**-53.9**	**852.3**	
Aviation Safety & Security	183.1	185.4	7.5	192.9	
Airspace Systems	232.3	152.2	48.1	200.3	
Vehicle Systems	641.4	568.6	-109.5	459.1	

Theme: Aeronautics Technology
Program: Aviation Safety and Security

President's FY 2006 Budget Request

(Dollars in Millions)

Aviation Safety and Security	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	183.1	185.4	192.9	173.5	170.5	176.2	176.3

Overview

The Aviation Safety and Security (AvSSP) program conducts research and technology that directly addresses the safety and security needs of the National Airspace System (NAS) and the aircraft that fly in the NAS. AvSSP will develop prevention, intervention, and mitigation technologies and strategies aimed at one or more causal, contributory, or circumstantial factors of aviation accidents. High priority is given to strategies that address the largest contributors to accident and fatality rates, as well as those that address multiple classes of factors. AvSSP will also develop concepts and technologies to reduce the vulnerability of aircraft and the NAS to criminal and terrorist attacks while dramatically improving the efficiency of security. AvSSP will also develop and integrate information technologies needed to build a safer and more secure aviation system, to support pilots and air traffic controllers, as well as provide information to assess situations and trends that might indicate unsafe or unsecure conditions before they lead to fatalities or damage.

The Aviation Safety and Security program conducts research and development targeted toward protecting air travelers and the public.

To accomplish the stated objectives, technology development activities will be managed within the following aviation security and safety projects: Aircraft and System Vulnerability Mitigation; Secure Aircraft Systems for Information Flow; System Vulnerability Detection; Aircraft Systems Self-Diagnosis and Self-Reliance; Integrated Flight Deck Information Systems, High Temperature Hazard Mitigation; Integrated Safety Data for Strategic Response; Threat and Human Error Management; and Design Tools and Operations for In-Flight Icing.

For information see: http://www.aero-space.nasa.gov/programs/program_org/as.html

Plans For FY 2006

As a technology development program, the AvSSP will provide technical capabilities and increase the likehood of technology implementation. Three Aviation Security projects--Aircraft System Vulnerability Mitigation, System Vulnerability Detection, and Secure Aircraft Systems for Information Flow--will define security concepts and requirements that provide reduced vulnerability from intentional attacks. In partnership with the FAA, the Commercial Aviation Safety Team (CAST), and the aviation community, Aviation Safety projects will provide an initial demonstration of a voluntary aviation safety information sharing process. This operational prototype of a proactive risk management system will be used by the aviation community for safety issue identification and resolution.

Program Management

ARMD Program Management Council has program oversight responsibility and authority. The Projects are implemented by ARC, GRC, LaRC, & JPL.

Technical Description

Aviation Security research and development commitment (FY 2004 through FY 2008) is two-fold: (1) demonstrate and deliver vehicle-based technologies that are designed to maximize the robustness of aircraft systems while addressing human behavior and decision-making requirements; and (2) demonstrate and deliver advanced security vulnerability discovery tools to monitor data sources for potential security issues, causal factors, and risk assessment.

Integrated Aviation System Safety Enhancements (FY 2006 through FY 2010) will focus on developing safety-enhanced concepts of operation for the future aviation system and developing technologies to transition the current system to the future state, while improving on current levels of safety.

Theme: Aeronautics Technology
Program: Aviation Safety and Security

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Vehicle Safety Technologies								Develop, demonstrate, and transfer technologies that protect and prevent damage to aircraft due to fire, fuel tank explosions, and loss of control from unusual attitude conditions.	Tech Form Dev Ops Res	Oct-97	Sep-05
System Safety Technologies								Develop, demonstrate, and transfer technologies to provides a pro-active system-wide approach to aviation safety risk mgmt. enabling a reduction in frequency & severity of undesired events	Tech Form Dev Ops Res	Oct-97	Sep-05
Weather Safety Technologies								Develop & foster the transfer of technologies that will reduce the role of atmospheric conditions (weather, including icing & turbulence) in aviation fatal accidents, incidents, and injuries	Tech Form Dev Ops Res	Oct-97	Sep-05
Aircraft & system vulnerability mitigation								Develop and advance technologies that will mitigate consequences to the aircraft from an intentional attack, and secure the flow of information to and on the aircraft.	Tech Form Dev Ops Res	Apr-04	Sep-09
System Vulnerability Detection								Identify and inform managers of existing, yet unidentified, and new security vulnerabilities within the air transportation system and mitigate the consequences of hostile acts	Tech Form Dev Ops Res	Apr-04	Sep-09
Secure Aircraft System for Information Flow								Develop technologies & concepts for a protected airspace surveillance system; remote monitoring of acft. onboard systems & environment; and secure &harden acft. datalinks & onboard networks	Tech Form Dev Ops Res	Oct-05	Sep-09
Aircraft Systems Self Diagnosis and Self-Reliance								Dev & demo technologies that automatically detect & correct degraded conditions in flight critical systems & structural components; and provide control resiliencey in unstable conditions	Tech Form Dev Ops Res	Oct-05	Sep-10
Integrated Flight Deck Info Systems								Advanced technology designs that promote optimal flight -crew performance, workload allocation, and situation awareness through the application of intuitive human-centered design principles	Tech Form Dev Ops Res	Oct-05	Sep-10
Threat and Human Error Management								Develop, demonstrate, and transfer technologies that prevent unsafe flight situations due to breakdown between human and machine interface	Tech Form Dev Ops Res	Oct-05	Sep-10
High Temperature Hazard Mitigation								Develop, demonstrate, and transfer technologies that detect hidden fires and provide real time hot section engine prognostics	Tech Form Dev Ops Res	Oct-05	Sep-10
Design Tools & Operations for In-Flight Icing								Develop & transfer technologies for sensing, fusing, and disseminating icing weather information; predicting in-flight icing effects; and improving weather hazards training	Tech Form Dev Ops Res	Oct-05	Sep-10
Integrated Safety Data for Strategic Response								Demonstrate a common time-delimited working prototype of a network-based integration of information sources allowing assessment of National Aviation System safety risk.	Tech Form Dev Ops Res	Oct-05	Sep-10

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

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Aviation System Vulnerability								Develop, demonstrate, and transfer technolgoies that inform and protect users of the Air Transportation System.	Tech Form Dev Ops Res	Oct-09	Sep-12

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

Strategy For Major Planned Acquisitions

- Secure Communication & Onboard Network research; award an advanced communication research tech. contract under full and open competition; complete task orders among sets of qualified contractors (TBD)
- Operator Intent Identification; seek release sources, anticipate full and open competition for contract. Performer TBD.
- Secure Airspace Decision Support Tool development; task to be added to previously competed contract. Performer is CSC.

Key Participants

- Existing partnerships for Safety research and technology development include Commercial Aviation Safety Team (CAST), General Aviation Joint Steering Committee (GAJSC), and a NASA/FAA Joint Working Group (JWG). Currently formalizing a partnership with TSA for security-specific activities.

Risk Management

- RISK: Given the uncertainties associated with advancing existing and introducing new revolutionary technologies, there is a possibility that cost and schedule may be impacted. MITIGATION: AvSSP will manage a balanced portfolio of revolutionary, as well as retrofit, technologies. AvSSP will monitor and track progress and maintain descope prioritization.
- RISK: Given the possibility that competing funding requirements draw funding away from research and development, there is a high probability that project activities may be descoped or eliminated. MITIGATION: AvSSP will monitor and track progress, and maintain descope prioritization for program, projects, and subprojects and leverage opportunities with other agencies and industry.
- RISK: Given customer need and requirements changes, there is a possibility that the long-range plans and strategic roadmap will need to be changed. MITIGATION: AvSSP will frequently monitor customer needs through participation in industry and other agency forums.
- RISK: Given the loss of critical workforce/skills/facilities, there is the possibility that cost and schedule may be impacted. MITIGATION: AvSSP will monitor and track progress using automated systems and scheduled/ad hoc reviews to assess budget, schedule, and technical status.

Theme: Aeronautics Technology
Program: Airspace Systems

President's FY 2006 Budget Request

(Dollars in Millions)

Airspace Systems	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	232.3	152.2	200.3	180.5	174.6	177.9	175.7

Overview

The Airspace Systems program develops advanced air transportation technologies, concepts, and modeling for a more efficient and global-interactive National Airspace System.

The Airspace Systems Program (ASP) enables revolutionary improvements and modernization of the National Airspace System, as well as the introduction of new systems for vehicles that can take advantage of an improved, modern, air transportation system. The ASP has identified three strategic foci: 1) Efficient Traffic Flow further develops aircraft operations and management efficiencies; 2) System-wide Operations Technologies maximize and expand operational efficiencies for the National Airspace System (NAS) with global interaction; and, 3) Airspace Human Factors enhance human performance, interaction and reliability in the use and design of complex systems.

ASP consists of seven projects categorized within these strategic foci. Efficient Aircraft Spacing develops technologies to aid aircraft in maintaining safe separation and efficient traffic flow. Efficient Flight Path Management develops tactical traffic management tools to maintain efficient traffic flow. Virtual Airspace Modeling and Simulation develops/assesses advanced system-level air transportation concepts. Small Aircraft Transportation System develops technologies to enable small aircraft to operate at non-towered/non-radar airports. Strategic Airspace Usage develops strategic traffic management tools and system-wide operations technologies. Space-based Technologies develops communications, navigation, and surveillance technologies, architectures, and systems. Finally, Human Measures and Performance develops fundamental knowledge for the efficient and safe operation of aviation systems by their human operators. For more information see: http://www.aero-space.nasa.gov/programs/program_org/asp.htm

Plans For FY 2006

ASP will continue to develop technical capabilities to increase the efficiency of the National Airspace System. Efficient Traffic Flow will, along with the FAA, develop technologies for coordinated aircraft operations and standards for wake vortex dependent operations. System-wide Operations Technologies will develop and validate modeling capabilities and develop global communication, navigation, and surveillance infrastructure technologies. Airspace Human Factors will conduct research aimed at bridging technology gaps for complex human-machine aviation systems. ASP will perform implementation planning for the Next Generation Aviation System through participation in the Inter-Agency Joint Planning and Development Office.

Theme: Aeronautics Technology
Program: Airspace Systems

Program Management

ARMD Program Management Council has program oversight responsibility and authority. The Projects are implemented by ARC, GRC, & LaRC.

Technical Description

The Airspace Systems program is working in cooperation with the FAA, airlines, controllers, and industry to create a vision for the future National Airspace System (NAS) that will safely accommodate the projected growth in air traffic and continue to be responsive to the needs of aviation communities around the globe. It is developing, demonstrating and transferring technologies that will modernize and enable revolutionary improvements to the NAS that will improve its throughput, predictability, flexibility, efficiency, and access while maintaining safety and environmental protection. The resultant benefit to the user will be reduced flight delays and doorstep-to-destination trip duration that will allow more people and goods to travel faster, anywhere, anytime, with fewer delays.

Implementation Schedule:

Project	Schedule by Fiscal Year 04 05 06 07 08 09 10	Purpose		Phase Dates Beg	End
Small Aircraft Transportation System (SATS)		Develop and demonstrate vehicle technologies to enable increased utilization of local and regional airports.	Tech Form Dev Ops Res	Oct-01	Oct-05
Virtual Airspace Modeling and Simulation (VAMS)		Develop future NAS operational concepts; develop modeling and simulation capability/ environment to assess new operational concepts at the domain and system level.	Tech Form Dev Ops Res	Oct-03	Oct-06
Efficient Aircraft Spacing (EAS)		Develop wake vortex operation procedures/standards to increase safety and capacity in the terminal area; develop distributed air/ground traffic management concepts.	Tech Form Dev Ops Res	Oct-04 Oct-03	Oct-08 Sep-04
Efficient Flight Path Management (EFPM)		Develop strategic planning tools for Air Traffic Service Providers and Airline Operations Centers, which reduce delays in the NAS while increasing system throughput.	Tech Form Dev Ops Res	Oct-04 Oct-03	Oct-08 Sep-04
Strategic Airspace Usage (SAU)		Develop long-term decision support tools ands strategic planning tools to evolve the NAS toward the envisioned future NAS.	Tech Form Dev Ops Res	Oct-04 Oct-03	Oct-08 Sep-04
Space-based Technologies (SBT)		Develop advanced communitations, navigation, and surveillance (CNS) technologies and architectures.	Tech Form Dev Ops Res	Oct-04 Oct-03	Oct-08 Sep-04
Human Measures and Performance (HMP)		Develop human performance measurements and design standards.	Tech Form Dev Ops Res	Oct-04	Oct-08
Technology Integration		Integrate technologies across project, domain, and infrastructure boundaries and conduct system studies and system analyses.	Tech Form Dev Ops Res	Oct-04	Oct-08
Transformation of the National Airspace System		Develop technology required for the establishment of an agile air traffic system that accommodates future requirements and readily responds to shifts in demand.	Tech Form Dev Ops Res	Oct-09	Sep-15

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

Strategy For Major Planned Acquisitions

- Software Development: full and open competition with University Affiliated Research Centers (UARC).
- Avionics development: full and open competition through cooperative agreements, with industry

Key Participants

- Existing partnerships include Joint NASA/ FAA Inter-Agency Product Team, Next Generation Aviation System of the Joint Planning and Development Office, FAA/Air Traffic Controllers, Airline Operations, and Aircraft pilots

Risk Management

- RISK: Given the uncertainties associated with advancing existing and introducing new revolutionary technologies, there is a possibility that cost and schedule may be impacted. MITIGATION: Airspace Systems (AS) will manage a balanced portfolio of revolutionary as well as retrofit technologies, monitor and track progress, and maintain descope prioritization.
- RISK: Given customer need and requirements changes, there is a possibility that the long-range plans and strategic roadmap will need to be changed. MITIGATION: AS will monitor of customer needs through participation in industry and other agency forums.
- RISK: Given the loss of critical workforce/skills/facilities, there is a possibility that cost and schedule may be impacted. MITIGATION: AS will monitor and track progress using automated systems and scheduled/ ad hoc reviews to assess budget, schedule, and technical status.
- RISK: Given the possibility that competing funding requirements draw dollars away from research and technology, there is a high probability that project activities may be descoped or eliminated. MITIGATION: AS will monitor and track progress, maintain descope prioritization for program, projects, and sub-projects, and leverage opportunities with other agencies and industry.

Theme: Aeronautics Technology
Program: Vehicle Systems

President's FY 2006 Budget Request

(Dollars in Millions)

Vehicle Systems	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	641.4	568.6	459.1	373.6	385.5	373.5	365.6

Overview

The Vehicle Systems program is transforming itself to better focus on demonstrations of breakthrough of aeronautics technologies for protecting the Earth's environment and enabling science missions. The program will demonstrate revolutionary technology concepts through flight demonstrators that are beyond the scope of conventional air vehicles. Preliminary plans are to focus on the four specific projects that are described. Over the next year, the program will work with the aeronautics community to define the scope of the overall program. The environmental focus will have two thrusts: noise reduction and emission reduction. Noise reduction work will address unconventional transport aircraft that are so quiet that objectionable noise would stay within the airport boundaries, and sonic boom mitigation strategies to determine what level of sonic boom is acceptable to the general population. Emissions reduction work will address the revolutionary zero-emissions aircraft, a hydrogen powered fuel-cell aircraft with cryogenic electronic motors embedded in the wings. The science and exploration focus will target the demonstrations of High-Altitude Long-Endurance Remotely-Operated Aircraft (HALE ROA) to achieve specific Earth and space science missions. A sequence of demonstrators is in development that will increase the durations, range, and payload of these air vehicles. Extensions of the same technologies will someday be used for flight in the atmosphere of Mars and other planets. For more information see: http://www.aero-space.nasa.gov/programs/program_org/vsp.htm

An F-5E, with a modified nose, starts a flight to demonstrate that sonic booms can be shaped. This special aircraft demonstrated that proper shaping of a supersonic aircraft could diminish the boom intensity and pave the way for quiet supersonic flight.

Plans For FY 2006

The program is planning to transform into four focused projects, each having a seperate activity for this year. The subsonic noise reduction project, will downselect components for reduction of fan, jet, and airframe noise that will be validated in a relevant environment to verify their potential to achieve 10dB noise reduction. The sonic boom reduction effort will focus on flight demonstration of component technologies to prove promising concepts for enhanced sonic boom mitigation. Trade studies will be completed to identify unconventional propulsion concepts that will enable realizing the goal of zero emission aircraft. The HALE-ROA project will demonstrate reconfigurable flight control architecture on a piloted vehicle, through flight testing. Policy changes will be proposed to the FAA, that would permit routine operation of HALE-ROA above 40,000 ft.

Theme: Aeronautics Technology
Program: Vehicle Systems

Changes From FY 2005

- Transform to focus on breakthrough flight demonstrations in four potential project areas of subsonic noise reduction, sonic boom mitigation, zero emissions aircraft, and HALE ROA.
- Reduce investment in conventional subsonic aircraft technology, including conventional turbomachinery and subsonic aerodynamics.
- Reduce dependence on large infrastructure investments and facilities through greater use of flight demonstrations and revolutionary vehicle concepts.

Program Management

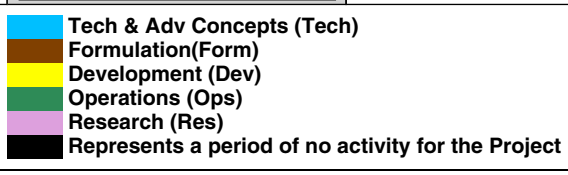
ARMD Program Management Council has program oversight responsibility and authority. The Projects are implemented by DFRC, GRC, & LaRC.

Technical Description

The program will demonstrate in-flight innovative, breakthrough capabilities for preserving our environment, and for conducting science missions. Specific capabilities to be developed over the next five years are: validate noise reduction for subsonic transport aircraft leading to a 10dB noise reduction relative to current best-in-fleet as demonstrated in flight on transport aircraft; demonstrate in flight a fully shaped supersonic aircraft will produce sonic boom levels substantially lower than conventional aircraft; demonstrate in flight a zero-emissions hydrogen fuel-cell powered aircraft; develop and demonstrate a 14-day duration HALE aircraft; and validate procedures for flying HALE ROA in the airspace above 18,000 feet.

Implementation Schedule:

Project	Schedule by Fiscal Year							Purpose	Phase Dates		
	04	05	06	07	08	09	10			Beg	End
Subsonic Noise Reduction								Flight demonstrated, validated 10dB noise reduction relative to the current best in fleet for subsonic transport category aircraft.	Tech Form Dev Ops Res	Oct-04	Sep-10
Sonic Boom Reduction								Demonstration in flight that a fully shaped supersonic aircraft will produce sonic boom levels substantially lower than conventional aircraft, enabling regulatory reconsideration.	Tech Form Dev Ops Res	Oct-05 Oct-04	Sep-11 Sep-05
Zero Emissions Demonstration								Flight demonstration of zero emissions aircraft using hydrogen fuel cells and eliminating aircraft emissions due to carbon dioxide and oxides of nitrogen.	Tech Form Dev Ops Res	Oct-05 Oct-04	Sep-11 Sep-05
High-Altitude Long-Endurance Remotely-Operated A/C								Flight demonstration of 14-day duration HALE ROA "hurricane tracker" with validated procedures for flying HALE ROA in the National Airspace System above 18,000 feet.	Tech Form Dev Ops Res	Oct-04	Sep-15



Strategy For Major Planned Acquisitions

- Foundational Technologies - peer-reviewed competitive grants and/or contracts for innovative technologies supporting flight demonstrations competed for awards of up to three years on a yearly basis.
- Artemis 14-day Duration HALE Demonstrator - peer-reviewed competitive contract to design and build a 10-day duration HALE aircraft.

Key Participants

- Government Agencies: DOT, FAA - Cooperation concerning aviation environmental compatibility, aircraft noise reduction technology, impact of aviation air emissions of climate and global atmospheric composition, and joint university research in air transportation.
- Industry: GE Aircraft Engines, Pratt & Whitney, Goodrich Corp., Lockheed Martin, Boeing, all participating in the subsonic noise reduction project. Other awardees anticipated for the demonstration aircraft.
- University: Pending foundational technology awards.

Risk Management

- RISK: Given significant cost overrun/schedule slip in a project deliverable, there is the possibility that lower priority activities may be descoped or eliminated. MITIGATION: Vehicle Systems (VS) will track progress using the Web-based automated monthly progress reporting system and maintain descope options based on priority.
- RISK: Given that technologies from other programs do not meet planned readiness levels, there is the possibility that this program's cost and schedule may be impacted. MITIGATION: VS will monitor and track development progress in other programs and maintain contingency plans.
- RISK: Given customer needs and requirement changes, there is the possibility that the 15-year roadmap will need to be updated. MITIGATION: VS will frequently monitoring of customer needs through the Vehicle Sector Managers.

Theme

Education Programs

NASA must motivate students to pursue careers in science, technology, engineering, and mathematics to ensure a pipeline of highly trained people are prepared to meet mission requirements with NASA, as well as in industry and academia.

EDUCATION

Purpose

To develop the next generation of explorers, NASA must do its part to inspire and motivate students to pursue careers in science, technology, engineering, and mathematics. NASA's mission to understand and explore depends upon educated, motivated people with the ingenuity to invent tools and solve problems and with the courage to always ask the next question. It is not enough to depend on the excitement generated by NASA's images of its achievements in space and on Earth; NASA must capitalize on that interest to provide meaningful education programs that will benefit the Agency and the Nation. To meet this challenge, education has become a core part of NASA's mission, and education programs are an integral part of every major NASA activity. To ensure a pipeline of highly trained people prepared to meet mission requirements within NASA, as well as in industry and academia, NASA must: motivate students to pursue careers in science, technology, engineering, and mathematics; provide educators with unique teaching tools and compelling teaching experiences; ensure that public resources are invested wisely; and fully engage minority and under-represented students, educators, and researchers in NASA's education programs. The Office of Education will strive to reach the masses of young people in the Nation to connect with, excite, and inspire the next generation of scientists, inventors, technicians, and explorers. For more information see: http://www.education.nasa.gov/home/index.html.

Education

FY 2004 Accomplishments

During FY 2004, NASA's Education Office made substantial progress in developing technologies that, when implemented, will support inspiring and motivating students as well as ways to measure this effort.

Educator Astronaut. NASA's Educator Astronaut (NEA) program facilitated 3 teachers joining the 2004 class of eleven new astronauts, which featured more Educator Astronauts than test pilots, and equal to the number of military officers, as well as qualifications were on par with any of the other astronauts selected in the past decade. The program also trained almost 200 teachers as its Network of Educator Astronaut Teachers (NEAT) who are expected to annually interact with approximately 9,000 colleague teachers to give them NASA content and teaching strategies for their classrooms.

Explorer Schools. The NASA Explorer Schools (NES) program increased the number of competitively selected participating schools to 100. Educators in these schools participate in a variety of individualized professional development activities where they are introduced to NASA materials ranging from lesson guides to interactive multimedia programs. As part of its effort to enhance digital content materials NASA conducted a technology assessment at 47 its Explorer Schools, indicating that the majority of these schools had limited technology capacity.

Informal Education. NASA engaged the informal education community through a numbers of collaborative initiatives: 1) NASA with its partner developed town reports assessing public perceptions and the needs of the informal community; 2) NASA sponsored a research project that created a database containing the years of community attitudes and survey results; 3) NASA conducted focus groups in eight locations across the country and a culture analysis; 4) NASA issued a grant to develop baselines and begin evaluation strategies for a festival, which bring together hundreds of middle-school girls for a festive day of science and inspiration.

e-Education. NASA reviewed existing learning technology and down-selected two cognitive tools to include in the NASA-sponsored Classroom of the Future's Virtual Design Center and continued to examine the benefits of three-dimensional visualization, comparative interfaces, graph sonification, and virtual data collection. NASA also hosted a Summer National Teacher Association Retreat on the topic of "Anticipating the Role of Emerging Technologies in Science Education," which will enable a new road mapping exercise.

Other Accomplishments. NASA's Science, Engineering, Mathematics, and Aerospace Academy (SEMAA) served just over 17,000 students in almost 800 primary and secondary schools and the Summer High School Apprenticeship Research Program (SHARP) placed almost 400 summer students as interns at NASA's Centers and partner universities.

Theme Distribution

Budget Authority ($ in millions)	FY 2004	FY 2005	FY 2006
Education Programs	230.4	216.8	167.0
Total	230.4	216.8	167.0

Note: For all formats, the FY 2004 column reflects the FY 2004 Congressional Operating Plan, dated 9/28/2004. The FY 2005 column reflects the FY 2005 Congressional Operating Plan, dated 12/23/2004. The FY 2006 column represents the FY 2006 President's Budget Submit.

Education

Education Programs

The Office of Education will provide unique teaching and learning experiences, as only NASA can, through the Agency's research and flight missions. Students and educators will be able to work with NASA and university scientists to use real data to study Earth, explore Mars, and conduct scientific investigations. They will work with NASA engineers to learn what it takes to develop technological breakthroughs required to reach the farthest regions of the solar system and to live and work in space. It is important that the next generation of explorers represents the full spectrum of the U.S. population, including minority students and those from low-income families. To ensure diversity in NASA's future workforce, Office of Education programs pay particular attention to under-represented groups. NASA Education will support the Nation's universities to educate more students in science and engineering by providing meaningful research and internship opportunities for qualified students, plus a roadmap for students seeking NASA careers.

Overall Budget

The FY 2006 request is $167.0 million:

- $28.4 million is requested for the Elementary and Secondary Education program to make available NASA-unique strategies, tools, content and resources supporting the K-12 education community's efforts that increase student interest and academic achievement in the science, technology, engineering, and mathematics (STEM) disciplines.
- $39.4 million is requested for the Higher Education program to attract and prepare students for NASA-related careers and to enhance the research competitiveness of the Nation's colleges and universities by providing opportunities for faculty and university-based research.
- $10.1 million is requested for the e-Education program to develop and deploy technology applications, products, services, and infrastructure that enhance the educational process for formal and informal education.
- $2.8 million is requested for the Informal Education program to bolster the informal education community efforts to inspire the next generation of explorers and enhance their capacity to engage in STEM education.
- $86.1 million is requested for the Minority University Research and Education program to prepare under-represented and under-served students for NASA-related careers, and to enhance the research competitiveness of minority-serving institutions by providing opportunities for faculty and university- and college-based research.
- Additional education-related funding is managed by NASA's scientific and technical Mission Directorates, in coordination with the Office of Education.

PATHFINDER INITIATIVES

The FY 2006 request includes $28.8 million to continue initiatives begun in the immediately preceding fiscal years:

- $3.3 million is requested for the Educator Astronaut program, which will select teachers and transport them into space to inspire and motivate students.
- $13.9 million is requested for the NASA Explorer Schools program, which will provide target middle schools with a customized and sustained learning environment using NASA's most recent discoveries and latest technologies to encourage greater interest in science and engineering careers.
- $8.9 million is requested for the Science and Technology Scholarship program, which will link scholarship with service at NASA Centers and help NASA better attract top students into its workforce.
- $2.7 million is requested for Explorer Institutes, NASA's direct link with the informal education community (science centers, museums, planetaria, and other informal education institutions) through openly competed grants.

Theme: Education Programs

Education Programs

The Exploration Generation -- NASA inspires the next generation of explorers...as only NASA can.

President's FY 2006 Budget Request (Dollars in Millions)

Education Programs	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	230.4	216.8	166.9	154.9	154.7	155.4	155.4
Changes from FY 2005 Request	4.1	48.3	-2.5	-15.7	-14.9	-14.9	

Overview: *What* NASA Accomplishes through the Education Programs Theme

Achieving NASA's mission depends upon educated, motivated people with the ingenuity to invent new tools, the passion to solve problems, and the courage to ask the difficult questions. It is not enough to depend on the excitement generated by NASA images. NASA must use its discoveries and achievements to engage students and the education community. To do so, NASA provides meaningful, educational, and content-rich programs to inspire and motivate students at all levels to pursue careers in science, technology, engineering, and mathematics (STEM). NASA Educaiton partners with academia, professional associations, industry, and other agencies to provide teachers and faculty with experiences that capitalize on the excitement of NASA's missions to spark student interest and involvement. Education Programs provides opportunities for involvement in NASA's research efforts to encourage students to pursue higher education in STEM areas. Finally, Education Programs engages the public in shaping and sharing the experience of exploration and discovery. With the FY 2006 budget request, NASA will continue the initiatives piloted in FY 2003 (Educator Astronaut and NASA Explorer Schools programs); in FY 2004 (NASA Explorer Institutes) in FY 2005 (NASA Science and Technology Scholarship program); and continue to more fully integrate all NASA Education activities into a seamless pipeline of exemplary programs to inspire the next generation of explorers and expand the pool of human capital resources available to meet NASA's needs. For more informaion see: http://education.nasa.gov/home/index.html

Theme: Education Programs

Relevance: *Why* NASA conducts Education Programs work

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

A lack of public understanding of scientific inquiry, a retiring aerospace workforce, and job recruitment competition for those with science and engineering degrees places future advancements in science, aeronautics and space exploration at risk. Preparing highly qualified students for science and engineering careers is imperative if the United States is to succeed in innovation. Preparing the teachers who will influence those students is equally imperative. The No Child Left Behind Act identifies the need to enhance achievement, while international comparisons in STEM subjects demonstrate that U.S. students do not achieve to international standards in science and mathematics. Nationally, employment opportunities in the S&E fields are projected to increase about three times faster than the rate for all occupations between 2000 and 2010. The number of retirees in these fields is projected to increase dramatically over the next 20 years. A scientifically literate citizenry is also critical to lend support to policy decisions involving science and technology.

Relevance to the NASA mission:

NASA has a strong connection with education in this country, as a beneficiary receiving top talent, and as a catalyst for inspiring interest in STEM. Building on this connection, NASA launched its pathhfinder initiatives: Educator Astronaut, Explorer Schools, Explorer Institutes, and the Science and Technology Scholarship programs.

Relevance to education and public benefits:

By supporting excellence in mathematics and science education and by coordinating with the Department of Education in the Math/Science Partnership, NASA Education helps broaden the reach of science and technology literacy programs to the education community and the general public. NASA Education is fully responsive to its stakeholders--taxpayers--by actively engaging with other Federal agencies and non-governmental professional education organizations.

Performance

Major Activities Planned for FY 2006:

- Continue NASA Education Pathfinder Initiatives and emphasize a seamless pipeline for all education programs that encourages students to excel in STEM disciplines.
- Ensure that NASA's Education portfolio addresses the needs of the the Nation by extending students affiliation, thereby expanding the human resource pool, primarily in the STEM disciplines.
- Continue implementation of the Aldridge Commission recommendations: 1) increase priority on teacher training; 2) better integrate STEM education; and, 3) explore option for "virtual space academy."

Major Recent Accomplishments:

- Realigned the education portfolio consistent with the Vision for Space Exploration.
- Launched the Science and Technology Scholarship program, awarding the first year of scholarships.
- Expanded the Explorer Schools program by selecting 50 additional schools, achieving three year goal of engaging 150 total schools.

Theme: Education Programs

Education Programs Theme Commitment in Support of the NASA Mission :

NASA Objectives

Multiyear Outcomes

Annual Performance Goals supporting the Multiyear Outcomes

13. Use NASA missions and other activities to inspire and motivate the Nation's students and teachers, to engage and educate the public, and to advance the scientific and technological capabilities of the Nation.

13.1 Make available NASA-unique strategies, tools, content, and resources supporting the K-12 education community's efforts to increase student interest and academic achievement in science, technology, engineering, and mathematics disciplines.

6ED1 Conduct 12 Educator Astronaut workshops, involving approximately 240 educators. (Elementary/2nd-Ed)

6ED2 Select approximately 150 student experiments, involving approximately 1,500 students, to participate in the Flight Projects program. (Elementary/2nd-Ed)

13.2 Attract and prepare students for NASA-related careers, and enhance the research competitiveness of the Nation's colleges and universities by providing opportunities for faculty and university-based research.

6ED3 Award approximately 1,500 competitive scholarships, fellowships, and research opportunities for higher education students and faculty in STEM disciplines. (Higher-Ed)

6ED4 Complete a retrospective longitudinal study of student participants to determine the degree to which participants entered the NASA workforce or other NASA-related career fields. (Higher-Ed)

6ED5 Collect, analyze, and report longitudinal data on student participants to determine the degree to which participants enter the NASA workforce or other NASA-related career fields. (Higher-Ed)

13.3 Attract and prepare underrepresented and underserved students for NASA-related careers, and enhance competitiveness of minority-serving institutions by providing opportunities for faculty and university- and college-based research.

6ED6 Award approximately 1,100 competitive scholarships, internships, fellowships, and research opportunities for underrepresented and underserved students, teachers and faculty in STEM disciplines. (MUREP)

6ED7 Provide approximately 350 grants to enhance the capability of approximately 100 underrepresented and underserved colleges and universities to compete for and conduct basic or applied NASA-related research. (MUREP)

6ED8 Select and support 50 additional schools to participate in the NASA Explorer Schools program, maintaining the total number at 150. (MUREP)

13.4 Develop and deploy technology applications, products, services, and infrastructure that would enhance the educational process for formal and informal education.

6ED9 Digitize and meta-tag up to 10% of NASA's approved learning materials to be delivered using technology-enabled learning systems. (e-Ed)

13.5 Establish the forum for informal education community efforts to inspire the next generation of explorers and make available NASA-unique strategies, tools, content, and resources to enhance their capacity to engage in science, technology, engineering, and mathematics education.

6ED10 Award competitive grants to NASA Centers and informal education partners to conduct up to 15 Explorer Institute workshops. (Informal-Ed)

Theme: Education Programs

Efficiency Measures

6ED11 Collect, analyze, and report the percentage of grantees that annually report on their accomplishments.

6ED12 Peer review and competitively award at least 80%, by budget, of research projects.

Program Management

Dr. Adena Williams Loston is the Chief Education Officer for NASA. The governing authority is the Education Program Management Council (EPMC).

Quality

Independent Reviews:

- Independent, credible evaluations conforming to federal guidelines and professional standards are being conducted to determine the effectiveness of two major programs, the Aerospace Education Services Program (AESP) and the NASA Explorer Schools (NES) program.
- Several management-led program reviews have been performed to capture the current state, needs, and recommendations from an array of NASA assets and customers. Findings from these reviews were used to make ongoing improvements to the eduction program portfolio. Future reviews will use the Education Program Operating Principles to evaluate program alignment and excellence.
- A peer review of all Space Grant consortia was conducted during FY 2004 as required by the Space Grant College and Fellowship authorizing legislation. Programmatic decisions based on the results of this peer review have been implemented, including the validation of performance criteria and the process for selecting new consortia, to ensure all operate at an acceptable level of performance.

Program Assessment Rating Tool (PART):

The Office of Management and Budget (OMB) analyzed the NASA Education program using the PART and rated the Education Programs as Adequate. OMB concluded NASA's Education Programs has the potential to attract students to science and technology careers. NASA has reviewed the PART findings and will begin in FY 2005 to implement actions that address these findings. In particular, NASA will place an increased emphasis on strategic planning and performance measurement to (a) better define expected outcomes, (b) identify appropriate measures, baselines, and tragets to document achievements, and (c) ensure that reliable, valid, and comprehensive performance data are collected, analyzed, and reported from all programs on an annual basis, with reports available to stakeholders, as appropriate. NASA will also conduct regular program reviews to (a) determine the degree to which programs are effective and relevant, (b) ensure an appropriate balance among programs, and (c) eliminate, enhance, or add programs. Additional efforts will be made to track participation, particularly by students, through the K-12, higher education, and other NASA Education programs to assess the effectiveness of these programs and to engage and maintain affiliation with NASA over time, leading to individuals joining the NASA's workforce.

Budget Detail

(Dollars in Millions)

Budget Authority ($ millions)	FY2004	FY2005	Change	FY2006	Comments
Education Programs	**230.4**	**216.8**	**-49.9**	**166.9**	
Elementary and Secondary Education	31.3	31.2	-2.7	28.5	
Higher Education	77.4	71.4	-32.0	39.4	
E-Education	9.7	10.6	-0.5	10.1	
Informal Education	5.5	10.8	-8.0	2.8	
Minority University Research and Education	106.6	92.8	-6.6	86.1	

Theme: Education Programs
Program: Elementary and Secondary Education

President's FY 2006 Budget Request

(Dollars in Millions)

Elementary and Secondary Education	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	31.3	31.2	28.5	25.3	24.7	25.6	25.7

Overview

NASA believes that by increasing the number of students involved in NASA-related activities at the elementary and secondary education levels more students will be inspired and motivated to pursue higher levels of study in science, technology, engineering, and mathematics (STEM) courses. The Elementary and Secondary Education program engages students, educators, families, and institutions through programs that are in place to: increase the rigor of STEM experiences provided to K-12 students through workshops, summer internships, and classroom activities; provide high-quality professional development to teachers in STEM through NASA programs; develop technological avenues through the NASA web site that will allow families to have common experiences with learning about space exploration; encourage inquiry teaching in K-12 classrooms; improve the content and focus of grade level/science team meetings in NASA Explorer Schools; and, share the knowledge gained through the Educator Astronaut program with teachers, students, and families.

By increasing the number of students involved in NASA-related activities at the elementary and secondary education levels more students will be inspired and motivated to pursue higher levels of study in science, technology, engineering, and mathematics (STEM) courses.

This Program also provides NASA flight opportunities to the diverse education community. These opportunities are available to educators and students nationwide via flight platforms such as the International Space Station (ISS), the Space Shuttle, Expendable Launch Vehicles (ELVs), Scientific Aircraft, Scientific Balloons, Sounding Rockets, and Small-Scale Rocketry. For more information see: http://education.nasa.gov/divisions/eleandsec/overview/index.html

Plans For FY 2006

NASA Education will continue to offer the following educational opportunities in FY 2006: NASA Educator Astronaut (NEA), the Aerospace Educator Services Program (AESP), and Flight Projects. Each of these efforts provides unique experiences for educators and students to share in the NASA discovery experience beginning in the very formative K-12 period. For example, the Educator Astronaut program will select a small number of outstanding educators to become members of the Astronaut Corps. These Educator Astronauts can then use the visibility and educational opportunities created by their experience to inspire greater K-12 STEM achievement, to promote STEM careers, and to elevate public esteem for the teaching profession.

Changes From FY 2005

- While maintaining its current portfolio, the program will evaluate individual projects to assure currency and to validate alignment with NASA missions and the Aldridge Commission recommendations.

Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

Technical Description

The Elementary and Secondary Education program is designed to provide students and educators with tools, experiences, and opportunities to further their education and participation in unique NASA learning experiences that enhance their knowledge of science, technology, engineering and mathematics (STEM). The individual efforts emphasize family involvement, which has been shown to enhance student achievement. The program also supports the role of educational institutions, which provide the framework to unite students, families, and educators for educational improvement. This program integrates new components with existing NASA assets into a structure that supports local education efforts to encourage student involvement in STEM.

Strategy For Major Planned Acquisitions

- A competitive cooperative agreement will be awarded to provide Nation-wide education and management support for the NASA Education portfolio.

Key Participants

- Primarily certified teachers from the selected schools, who will be provided professional development in STEM subject areas.
- Elementary and Secondary Education activities may involve astronauts, engineers, scientists, and mathematicians from the public and private sectors addressing NASA's related disciplines and topics.

Risk Management

- RISK: Elementary and Secondary Education is a relatively low risk program. The primary risk is a loss of affiliation with principal participants resulting in the loss of opportunity to reach the student audience. Loss of affiliation is most often attributed to funding disruption or stoppage or to issues with informational material currency and availability. MITIGATION: NASA Education will monitor and mitigate program risk through continual evaluation of both program content and delivery method, adjusting the content or delivery method to assure currency. Also, NASA will carefully monitor funding levels and flow to ensure continual engagement with current and intended funding recipients.

Theme: Education Programs
Program: Higher Education

President's FY 2006 Budget Request

(Dollars in Millions)

Higher Education	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	77.4	71.4	39.4	36.7	36.8	36.7	36.7

Overview

Higher Education supports students and faculty at universities and colleges to strengthen their research capabilities and provide opportunities that attract and prepare increasing numbers of students for NASA-related careers. Participation in NASA programs and research can stimulate increasing numbers of students to continue their studies at all levels of the higher education continuum and to earn advanced degrees in science, technology, engineering, and mathematics (STEM). In addition, the research conducted at the institutions of higher education will contribute to the research needs of NASA's Mission Directorates.

NASA supports students and faculty at universities and colleges to strengthen their research capabilities and provide opportunities that attract and prepare increasing numbers of students for NASA-related careers.

The Higher Education projects are intended to serve as a major link in the student pipeline used to address NASA's Human Capital Strategies and the President's Management Agenda by helping to " ... build, sustain, and effectively deploy the skilled, knowledgeable, diverse, and high performing workforce needed to meet the current and emerging needs of government and its citizens."

The major project in the Higher Education portfolio include: 1) Science and Technology Scholarship Program (STSP); 2) Graduate Student Research Program (GSRP); 3) National Space Grant College and Fellowship Program; and 4) Experimental Program to Stimulate Competitive Research (EPSCoR). For more information see: http://education.nasa.gov/divisions/higher/overview/index.html

Plans For FY 2006

The Higher Education program will continue to engage students and universities through a wide variety of initiatives, with particular focus on the NASA STSP, NASA Space Grant, the GSRP, and the EPSCoR. NASA Education will continue to facilitate its work through competitive research announcements, cooperative agreement notices, and other procurement vehicles, and multi-year grants awarded to institutions and students in research pertinent to NASA missions. These efforts will provide recipients with assistance for their participation in collaborative scientific and/or engineering research or education projects which should lead to even stronger scientific and technical infrastructure of participating institutions. All Higher Education projects will continue to focus on retaining students in STEM disciplines through their completion of undergraduate or graduate degrees and entry into the scientific and technical workforce.

Changes From FY 2005

- Higher Education will again evaluate its individual efforts to minimize duplication, provide better alignment with NASA missions, and to ensure a more competitive award process.
- Next phase implementation of the Science and Technology Scholarship Program (STSP), with initial new hires under the service component of the STSP.
- NASA will complete the phase out begun in FY 2005 of the Undergraduate Student Research Program (USRP) because students in the STSP are required to participate in research internships.

Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

Technical Description

Higher Education focuses on supporting institutions of higher education in strengthening their research capabilities and providing opportunities that attract and prepare increasing numbers of students for NASA-related careers, primarily in the STEM disciplines.

Strategy For Major Planned Acquisitions

- Higher Education will continue to award multi-year grants to institutions and students using a mix of competitive research and cooperative agreements or other appropriate procurement vehicles.

Key Participants

- Students and institutional researchers (both basic and applied) from selected higher education institutions.
- Higher Education activities may involve astronauts, engineers, scientists, and mathematicians from public and private sectors addressing NASA's related disciplines and topics.

Risk Management

- RISK: Higher Education is a relatively low risk program. The primary risk is a loss of affiliation with a principal participant resulting in an inability to meet NASA's and the country's future workforce needs in scientific and technical disciplines. Loss of affiliation is often attributed to funding disruption or stoppage to a primary participant, and to a lack of currency in the funding targets. MITIGATION: NASA Education will monitor and mitigate program risk through continual evaluation of program performance and relevance, adjusting the portfolio to ensure an appropriate mix. Also, NASA will carefully monitor funding levels and flow to ensure continual engagement with current and intended funding recipients.

Theme: Education Programs
Program: E-Education

President's FY 2006 Budget Request

(Dollars in Millions)

E-Education	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	9.7	10.6	10.1	8.9	9.0	9.0	8.9

Overview

In the future, powerful technologies will enable new learning environments using simulations, visualizations, immersive environments, game-playing, and learner networking. These capabilities will create rich and compelling learning opportunities that meet the needs of learners while empowering educators and other adults to unlock a student's mind and their own potential. Learning will be on demand. Students, educators, and the general public will receive what they need, when they need it anywhere, anytime. NASA is working toward this education future, developing new methods for making its exciting discoveries and valuable resources available to students, educators, and the public.

The Picture entitled: "Technology moves in mysterious ways -- Exciting, inspiring, and educating the public with NASA technology ...as only NASA can."

The intent of e-Education is to develop infrastructure and deploy research-based technology applications, products, and services that enhance the educational process for formal and informal education. Furthermore, activities under e-Education directly support the President's Management Agenda for e-Government.

The e-Education portfolio includes the assets of Digital Learning Network (DLN), Learning Technologies Projects (LTP), NASA-sponsored Classroom of the Future (COTF), Education File on NASA TV, Web services, including the NASA Public Portal and Education home page, the suite of television and Web-based instructional series, and electronic- and site-based dissemination network. For more information see: http://education.nasa.gov/divisions/techprodoffice/overview/index.html

Plans For FY 2006

NASA e-Education will continue to develop common procedures, capabilities, and tools to ensure that education programs and products capture the essence of NASA and are exciting and relevant to NASA Education's constituencies. At the same time NASA will pursue an enhanced technology infrastructure to support delivery of and increased access to NASA content, programs, and projects by students, educators, and public. NASA e-Education will continue to partner with mission directorates and other NASA organizations to create rich, effective learning experiences and connections for a range of audiences. And, e-Education will continue its implementation of an integrated DLN throughout NASA.

Theme: Education Programs
Program: E-Education

Changes From FY 2005

- NASA e-Education will evaluate its individual efforts to minimize duplication, to provide better alignment with NASA missions, and to ensure responsiveness to the Aldridge Commission recommendations.
- Project management of the Learning Technologies Project (LTP) will transition from Ames Research Center to the Office of Education following field project conclusion in FY 2005.
- e-Education will operate with a new competitive cooperative agreement for educational technology research, learning tools and evaluation conducted through its Classroom of the Future (COTF) project.

Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

Technical Description

NASA e-Education explore ways to maximize technology's contribution to redefining and enhancing education by seeking partnerships with the private sector, the academic research community, teachers, and other key stakeholders to speed the development of these technologies. NASA e-Education fosters public-private collaborations to develop advanced technologies, such as interactive, virtual-presence, and immersive environments and interfaces to remote instruments, that integrate the agengy's science and engineering capabilities in order to strengthen K-12 science and mathematics education. NASA e-Education also provides telepresence experiences, "tools," and digital resources to aid curriculum developers, educators and informal education communities.

Strategy For Major Planned Acquisitions

- A competitive cooperative agreement for ongoing services is expected for educational technology research, learning tools and evaluation conducted through its COTF project.

Key Participants

- e-Education activities may involve astronauts, engineers, scientists, and mathematicians from public and private sectors addressing NASA's related disciplines and topics.

Risk Management

- RISK: NASA e-Education is a relatively low risk program. The primary risk is a loss of affiliation with principal participants resulting in the loss of opportunity to reach the targeted audience. Loss of affiliation is most often attributed to a lack of informational material currency, to funding disruption or stoppage, or to issues related to technology deployment. MITIGATION: NASA Education will monitor and mitigate program risk through continual evaluation of both program content and delivery method, adjusting the content and deployed technology to assure currency. Also, NASA will carefully monitor funding levels and flow to ensure continual engagement with current and intended funding recipients.

Theme: Education Programs
Program: Informal Education

President's FY 2006 Budget Request

(Dollars in Millions)

Informal Education	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	5.5	10.8	2.8	2.4	2.4	2.4	2.4

Overview

NASA continues to seek opportunities for partnerships and alliances with national, state and local education organizations; industry; and academic institutions to encourage and provide access for more students and citizens to become active participants in our aviation research and technology and space exploration. The Nation's science centers, museums, planetaria, libraries, community-based organizations, and other informal education entities are a major source of inspiration and learning for people from all walks of life.

Informal Education provides stimulating experiences for science, technology, engineering, and mathematics learning outside of formal classroom environments.

Informal Education provides stimulating experiences for science, technology, engineering and mathematics (STEM) learning outside of formal classroom environments through media, exhibits, and community-based programming. Its goals are to increase interest in, understanding of, and engagement with, STEM disciplines by individuals of all ages; to establish linkages between informal and formal education; and to stimulate parents and others to support their children's STEM learning endeavors and to become informed proponents for high-quality, universally available STEM education.

As NASA builds relationships with informal education institutions, all participants are better equipped to engage the public in shaping and sharing the experience of exploration and discovery and to improve public understanding and appreciation of science and technology. For more information see: http://education.nasa.gov/divisions/informal/overview/index.html

Plans For FY 2006

Informal Education will continue to focus on its pathfinder initiative, NASA Explorer Institutes (NEI) as a way to broaden NASA's reach to students, their families, and the general public by strengthening the capacity of the informal education community, including science centers, museums, planetaria, and community-based organizations. The program will continue to establish linkages that promote new relationships between providers of informal and formal education, resulting in improved and creative STEM education in all learning environments. For example, the program will continue to sponsor workshops on the STEM disciplines through NASA Centers in order to better reach the traditionally underrepresented and underserved educational community. A focus for these workshops is to improve the public understanding and appreciation of STEM disciplines and to enhance their scientific and technological literacy, mathematical competence, problem-solving skills, and the desire to learn.

Theme: Education Programs
Program: Informal Education

Changes From FY 2005

- Informal Education will evaluate its individual efforts to minimize duplication and to provide better alignment with NASA missions and the Aldridge Commission recommendations.
- The NASA Explorer Institute (NIE) will move from a start-up phase to full implementation, with formative and external summative evaluations developed on the NIEs.

Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

Technical Description

In cooperation with the Mission Directorates and the Office of Public Affairs, the Office of Education leverages its partnerships with existing and future informal education partners to share NASA discoveries and experiences. Following its coordinated plan for the implementation of the NEIs, NASA engages science centers, museums, planetaria, community-based organizations, and other public forums to assist sharing these discoveries and experiences. The NASA Office of Education facilitates development of educational materials that incorporate these new discoveries and disseminates them to its partners.

Key Participants

- The Nation's science centers, museums, planetariums, libraries, community-based organizations, and other informal education entities.

Risk Management

- RISK: Informal Education is a relatively low risk program. The primary risk is a loss of affiliation with principal participants resulting in the loss of opportunity to reach the targeted audience. Loss of affiliation is most often attributed to a lack of informational material currency, to funding disruption or stoppage, or to issues related to technology deployment. MITIGATION: NASA Education will monitor and mitigate program risk through continual evaluation of both program content and delivery method, adjusting the content and deployed technology to assure currency. Also, NASA will carefully monitor funding levels and flow to ensure continual engagement with current and intended funding recipients.

Theme: Education Programs
Program: Minority University Research and Education

President's FY 2006 Budget Request

(Dollars in Millions)

Minority University Research and Education	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	FY2010
FY 2006 PRES BUD	106.6	92.8	86.1	81.6	81.8	81.7	81.6

Overview

NASA's outreach to minority institutions through its Minority University Research and Education Program (MUREP) will expand the Agency's research base through continued investment in minority institutions' research and academic infrastructure; contribute to the development of the science, technology, engineering, and mathematics pipeline; and inspire the next generation of explorers.

NASA's outreach to minority institutions contribute to the development of science, technology, engineering, and mathematics.

The NASA MUREP will achieve its objectives by employing a comprehensive and complementary array of strategies, which will include (1) developing new research and education collaborations and partnerships with the NASA Mission Directorates, other government agencies, and interested parties; (2) providing and encouraging opportunities for faculty to conduct NASA research early in their careers; (3) providing financial and other support for students to enter and complete degrees in STEM disciplines; (4) establishing measurable program goals and objectives; and (5) developing and implementing evaluation models to assess the effectiveness and outcomes of the programs and their financial performance, thereby improving program delivery and results. MUREP awards focus on building and supporting successful pathways for students to progress to higher levels of mathematics and science. For more information see: http://www.nasa.gov/audience/foreducators/MUREP.html

Plans For FY 2006

The MUREP program will continue to engage under-represented populations through a wide variety of initiatives, with particular focus on the NASA Explorer Schools and the Summer High School Apprenticeship Research Program (SHARP) projects. NASA Education will continue to facilitate its work through competitive research announcements, cooperative agreement notices, and multi-year grants awarded to minority institutions, faculty and students in research pertinent to NASA missions. These efforts will provide Minority Serving Institutions (MSIs) with assistance for their participation in collaborative scientific and/or engineering research or education projects which will lead to even stronger scientific and technical infrastructure of MSIs. All MUREP projects will continue to focus on retaining underrepresented and underserved students in a STEM discipline through their completion of undergraduate or graduate degrees and entry into the scientific and technical workforce.

Changes From FY 2005

- Similar to other NASA Education programs, MUREP will evaluate its individual efforts to minimize duplication, provide better alignment with NASA missions, and to ensure a competitive award process.
- The Minority Institutions of Excellence (MIE) and Institutional Research Awards (IRA) efforts are being phased out with these needs addressed through the University Research Centers (URCs).
- Other efforts, for example MASTAP, NRTS and PAIR, have been restructured to better align with the concepts and recommendations of the Aldridge Commission report.

Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

Technical Description

MUREP is administered through NASA's Office of Education to increase the agency's responsiveness to Federal mandates related to Historically Black Colleges and Universities (HBCUs) and Other Minority Universities (OMUs), including Hispanic Serving Institutions (HSIs) and Tribal Colleges and Universities (TCUs). The programming staff is responsible for formulating and executing NASA's Minority University Research and Education Program (MUREP) budget, developing agency-wide policies, procedures and guidelines that enhance the involvement of HBCUs and OMUs in the mission of the Agency.

Strategy For Major Planned Acquisitions

- MUREP will continue to award multi-year grants to minority institutions, faculty and students using a mix of competitive research and cooperative agreements or other appropriate procurement vehicles.

Key Participants

- Students, faculty and researchers from HBCUs and OMUs, including HSIs and Tribal Colleges and Universities (TCUs).
- MUREP activities may involve astronauts, engineers, scientists, and mathematicians from public and private sectors addressing NASA's related disciplines and topics.

Risk Management

- RISK: The MUREP is a relatively low risk program. The primary risk is a loss of affiliation with the principal particpants resulting in an inability to meet NASA's and the country's future workforce needs in scientific and technical disciplines. Loss of affiliation is often attributed to funding disruption or stoppage to the primary participants, and to a lack of currency in the funding targets. MITIGATION: NASA Education will monitor and mitigate program risk through continual evaluation of program performance and relevance, adjusting the portfolio to ensure an appropriate mix. Also, NASA will carefully monitor funding levels and flow to ensure continual engagement with current and intended funding recipients.