



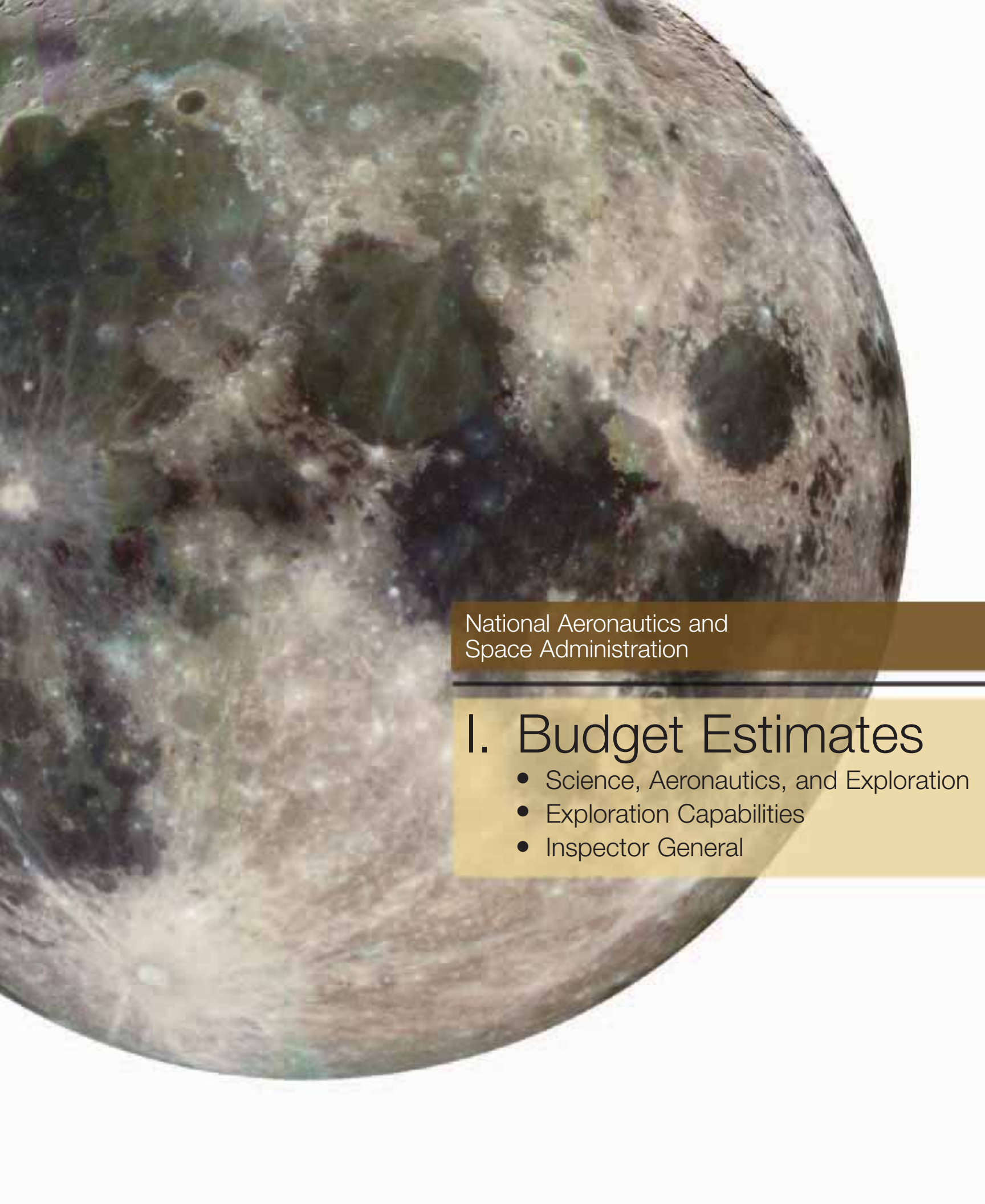
FISCAL YEAR  
**2006**

National Aeronautics and  
Space Administration

## I. Budget Estimates

- Science, Aeronautics, and Exploration
- Exploration Capabilities
- Inspector General

## II. Supplementary Information



National Aeronautics and  
Space Administration

# I. Budget Estimates

- Science, Aeronautics, and Exploration
- Exploration Capabilities
- Inspector General

**National Aeronautics and Space Administration  
President's FY 2006 Budget Request**

| <b>(Budget authority, \$ in millions)</b>    |                 | <b>FULL COST</b>                                   |                 |                 |                 |                 |                  | <b>Chapter Number</b> |
|--|-----------------|--|-----------------|-----------------|-----------------|-----------------|------------------|-----------------------|
| By Appropriation Account                     |                 | <b>Initial<br/>Operating<br/>Plan<br/>12/23/04</b> |                 |                 |                 |                 |                  |                       |
| By Mission Directorate                       |                 | <u>FY 2005</u>                                     | <u>FY 2006</u>  | <u>FY 2007</u>  | <u>FY 2008</u>  | <u>FY 2009</u>  | <u>FY 2010</u>   |                       |
| By Theme                                     |                 |  |                 |                 |                 |                 |                  |                       |
| <b>Science, Aeronautics, and Exploration</b> | <b>9,334.7</b>  | <b>9,661.0</b>                                     | <b>10,549.8</b> | <b>11,214.6</b> | <b>12,209.6</b> | <b>12,796.1</b> | <b>SAE SUM-1</b> |                       |
| <b>Science*</b>                              | <b>5,527.2</b>  | <b>5,476.3</b>                                     | <b>5,960.3</b>  | <b>6,503.4</b>  | <b>6,853.0</b>  | <b>6,797.6</b>  | SAE 1            |                       |
| Solar System Exploration                     | 1,858.1         | 1,900.5  | 2,347.7         | 2,831.8         | 2,998.9         | 3,066.1         | SAE 2            |                       |
| The Universe                                 | 1,513.2         | 1,512.2  | 1,531.5         | 1,539.4         | 1,495.0         | 1,406.7         | SAE 3            |                       |
| Earth-Sun System                             | 2,155.8         | 2,063.6  | 2,081.2         | 2,132.2         | 2,359.0         | 2,324.8         | SAE 4            |                       |
| <b>Exploration Systems**</b>                 | <b>2,684.5</b>  | <b>3,165.4</b>                                     | <b>3,707.0</b>  | <b>3,825.9</b>  | <b>4,473.7</b>  | <b>5,125.5</b>  | SAE 5            |                       |
| Constellation Systems                        | 526.0           | 1,120.1  | 1,579.5         | 1,523.7         | 1,990.9         | 2,452.2         | SAE 6            |                       |
| Exploration Systems Research and Technology  | 722.8           | 919.2  | 907.3           | 989.2           | 1,050.3         | 1,078.5         | SAE 7            |                       |
| Prometheus Nuclear Systems and Technology    | 431.7           | 319.6  | 423.5           | 500.6           | 614.0           | 779.0           | SAE 8            |                       |
| Human Systems Research and Technology        | 1,003.9         | 806.5  | 796.7           | 812.4           | 818.5           | 815.8           | SAE 9            |                       |
| <b>Aeronautics Research</b>                  | <b>906.2</b>    | <b>852.3</b>                                       | <b>727.6</b>    | <b>730.7</b>    | <b>727.5</b>    | <b>717.6</b>    | SAE 10           |                       |
| Aeronautics Technology                       | 906.2           | 852.3  | 727.6           | 730.7           | 727.5           | 717.6           | SAE 11           |                       |
| <b>Education Programs</b>                    | <b>216.7</b>    | <b>166.9</b>                                       | <b>154.9</b>    | <b>154.7</b>    | <b>155.4</b>    | <b>155.4</b>    | SAE 12           |                       |
| Education Programs                           | 216.7           | 166.9  | 154.9           | 154.7           | 155.4           | 155.4           | SAE 13           |                       |
| <b>Exploration Capabilities</b>              | <b>6,704.4</b>  | <b>6,763.0</b>                                     | <b>6,378.6</b>  | <b>6,056.7</b>  | <b>5,367.1</b>  | <b>5,193.8</b>  | <b>EC-SUM 1</b>  |                       |
| <b>Space Operations</b>                      | <b>6,704.4</b>  | <b>6,763.0</b>                                     | <b>6,378.6</b>  | <b>6,056.7</b>  | <b>5,367.1</b>  | <b>5,193.8</b>  | EC 1             |                       |
| International Space Station                  | 1,676.3         | 1,856.7  | 1,835.3         | 1,790.9         | 2,152.3         | 2,375.5         | EC 2             |                       |
| Space Shuttle                                | 4,543.0         | 4,530.6  | 4,172.4         | 3,865.7         | 2,815.1         | 2,419.2         | EC 3             |                       |
| Space and Flight Support                     | 485.1           | 375.6  | 370.9           | 400.0           | 399.7           | 399.1           | EC 4             |                       |
| <b>Inspector General</b>                     | <b>31.3</b>     | <b>32.4</b>  | <b>33.5</b>     | <b>34.6</b>     | <b>35.2</b>     | <b>37.3</b>     | IG 1             |                       |
| <b>TOTAL</b>                                 | <b>16,070.4</b> | <b>16,456.3</b>                                    | <b>16,962.0</b> | <b>17,305.9</b> | <b>17,611.9</b> | <b>18,027.1</b> |                  |                       |
| Year to year increase                        |                 | 2.4%   | 3.1%            | 2.0%            | 1.8%            | 2.4%            |                  |                       |
| Emergency Hurricane Supplemental             | 126.0           |  |                 |                 |                 |                 |                  |                       |

\*Science Mission Directorate reflects the combination of the former Space Science and Earth Science Enterprises.

\*\*Beginning in FY 2006, Exploration Systems moves from Exploration Capabilities to Science, Aeronautics and Exploration. Exploration Systems Mission Directorate reflects the combination of the former Biological & Physical Research and Exploration Systems Enterprises.

Totals may not add due to rounding.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



***FY 2006 Budget Request Summary***

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### The Exploration Vision is Well Under Way

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On January 14, 2004, President George W. Bush announced *A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration*, a new directive for the Nation's future in space exploration. The fundamental goal of this directive is "...to advance U.S. scientific, security, and economic interests through a robust space exploration program." In issuing it, the President committed the Nation to a journey of exploration, returning humans to the Moon by the year 2020, then venturing further into the solar system, ultimately sending humans to Mars and other destinations. He challenged NASA to establish new and innovative programs to enhance understanding of the planets, ask new questions, and answer questions as old as humankind.

The *Vision for Space Exploration*, published in February 2004, embodies the strategy and guiding principles NASA will follow in pursuing the President's directive. The *Vision* lays out important, fundamental goals and embodies a strategy of specific milestones that will move NASA and the Nation forward in the years to come.

The President demonstrated his commitment to the *Vision for Space Exploration*, and Congress supported this commitment, with full funding for NASA at the budget level requested for FY 2005. The President reaffirmed this commitment by providing NASA with a 2.4 percent increase for FY 2006 to meet established critical priorities and milestones.

The FY 2006 budget identifies what is needed to continue transforming America's civil space program. It preserves the priorities, milestones, and schedules introduced with the *Vision* in the FY 2005 budget, and it supports NASA's continuing organizational and cultural transformation through new management organizations and a revised budget structure consistent with the recommendations of the *President's Commission on Implementation of the United States Space Exploration Policy* (Aldridge Commission). The budget for FY 2006 continues to support the *Vision for Space Exploration* and is reflected in *The New Age of Exploration: NASA's Direction for 2005 and Beyond*, a new document that outlines NASA's strategic planning efforts and the Agency's commitment to implementing and achieving the *Vision*. *The New Age of Exploration* also establishes the new NASA Strategic Objectives that are reflected in the FY 2006 Budget.

The 2006 budget maintains a focus on key exploration priorities and critical milestones informed by NASA's science priorities:

- First Step—Space Shuttle return to flight and completion of International Space Station assembly.
- Flagship Program—Project Constellation (maintain 2008 CEV flight demonstration).
- Technology Base—Critical exploration technologies.
- Transforming Technologies—Project Prometheus (flight demonstration in a decade).
- Robotic Precursors—Lunar missions beginning in 2008 and Mars missions added in 2011.
- Shuttle Transition—ISS cargo and crew services via near-term commercial service.
- Scientific Breakthroughs—Exploration of the solar system and the universe (e.g., James Webb Space Telescope to be launched in 2011) and the search for Earth-like planets.

The budget also supports critical national needs and revolutionary technologies in aeronautics, climate change, and education.



## Transforming NASA

Guided by NASA's core values of Safety, the NASA Family, Excellence, and Integrity, the Agency is changing to meet the needs the *Vision*. First, NASA is embedding a safety culture throughout the organization. The Agency has reduced workforce accident rates to industrial world-class standards and implemented an Independent Technical Authority to guide NASA's continued improvement.

NASA is embracing competition. The Agency is using competitive processes to elicit the best from industry, academia, and NASA's Centers. NASA is seeking innovation from all sources by casting a broad net worldwide in search of beneficial partnerships and innovative solutions to technical and management challenges.

NASA is enhancing the Agency's long range planning processes and improving decision-making. The Agency's transformed structure includes a Strategic Planning Council and a supporting Office of Advanced Planning and Integration to enable better long-range planning, an Operations Council to integrate NASA's tactical and operational decisions, and a revised advisory council to integrate Agency activities. And, NASA's 2006 Strategic Plan will be based on a set of strategic and capability roadmaps currently being developed by national teams of external and NASA experts to ensure that NASA's activities are aligned with the *Vision for Space Exploration*.

NASA has streamlined the Agency's corporate structure by cutting the number of Headquarters organizations in half. As of August 2004, NASA has four Mission Directorates—Exploration Systems, Space Operations, Science, and Aeronautics Research—and eight Mission Support Offices, including the Office of Education and the Office of Safety and Mission Assurance. And, to reinvigorate NASA's Centers, Agency leaders are identifying core competencies and reviewing possible alternate management structures for NASA's Centers.

Finally, NASA is building a sound management foundation. NASA scored well on the President's Management Agenda initiatives in 2004, especially in developing and implementing new tools to recruit the next generation of engineers, scientists, and astronauts.

The President's Policy Directive



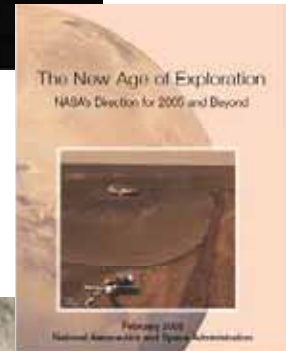
NASA's response to *The President's Vision for U.S. Space Exploration*.



The Aldridge Commission Report on how NASA should proceed with implementing *The Vision for Space Exploration*.



NASA's strategic planning efforts for pursuing and fulfilling *The Vision for Space Exploration*.



NASA's FY 2006 Budget Request details how *The Vision for Space Exploration* and its related activities will be funded and sustained.



### Making Great Progress

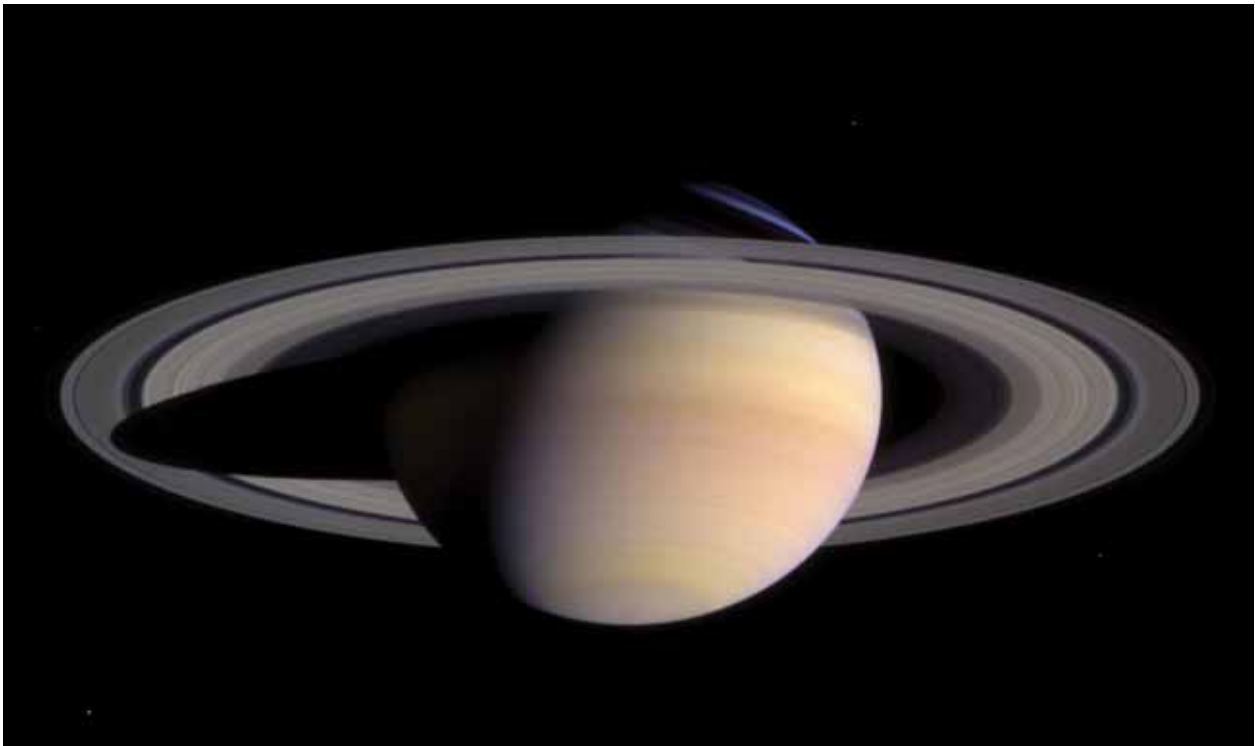
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NASA's transformation and journey to achieving the *Vision for Space Exploration* is off to a strong start. NASA is making final preparations to return the Space Shuttle to flight, and this year NASA began its fifth year of continuous astronaut presence in space aboard the International Space Station.

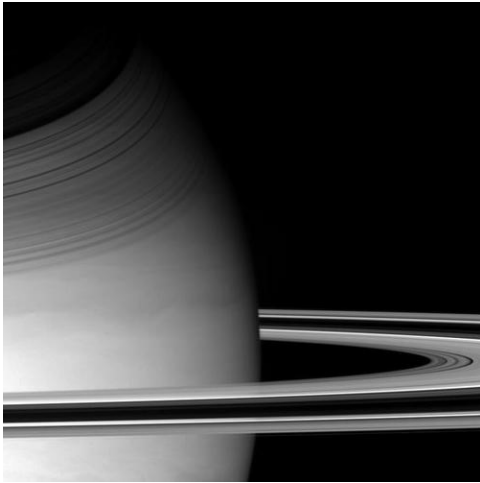
NASA is moving further into the solar system. The Mars rovers, *Spirit* and *Opportunity*, are exceeding all goals with their unprecedented discoveries and longevity. They found definitive evidence of water on the Red Planet and continue to gather data more than a year after their successful landing. The Cassini–Huygens spacecraft entered Saturn's orbit and sent back breathtaking images of that planet's rings and moons. The Genesis mission successfully returned primordial samples from space. MESSENGER launched to visit and map Mercury while NASA's eyes in the sky, including Hubble, Chandra, and Spitzer, continued to amaze the world with images from the deepest reaches of space. And, with NASA's international partners, the Agency added to the constellation of Earth observing satellites that monitor this fragile planet.

NASA also is laying the groundwork for the future. The Agency competitively awarded 118 contracts for exploration technologies based on an overwhelming response to the call for proposals. NASA began the Crew Exploration Vehicle competition process, and flight demonstrations are planned for 2008. The Agency is putting the building blocks in place to return astronauts to the Moon, and early preparations have begun – including system design and technology tests for nuclear power in place – to ensure that explorers head for Mars and other destinations on schedule.

NASA and the *Vision for Space Exploration* are generating worldwide excitement. Over 17 billion hits on NASA's Web site is evidence of public interest in America's space exploration program.



## Science Mission Directorate

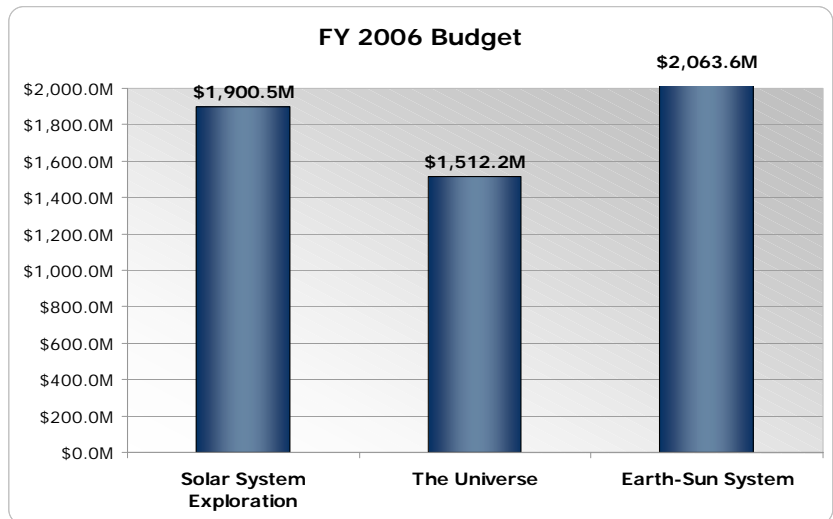


The newly organized Science Mission Directorate (SMD) engages the Nation's science community, sponsors scientific research, and develops and deploys satellites and probes in collaboration with NASA's partners around the world to answer fundamental questions requiring the view from and into space. SMD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

The Science Mission Directorate also sponsors research that both enables, and is enabled by, NASA's exploration activities. The SMD portfolio is contributing to NASA's achievement of the *Vision for Space Exploration* by striving to:

- Understand the history of Mars and the formation of the solar system. By understanding the formation of diverse terrestrial planets (with atmospheres) in the solar system, researchers learn more about 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 while supporting safe robotic and human exploration of space. 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. SMD's pursuit of interdisciplinary scientific research focus areas will help predict potentially harmful conditions in space and protect NASA's robotic and human explorers.

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 activities directly supporting the *Vision for Space Exploration* and investigations of the structures and processes at work in the universe to studies of Earth, NASA's Science Mission Directorate will continue to build upon its past successes.



## 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 pursues 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 will continue to determine the planet's physical, dynamic, and geological characteristics. It will also investigate both the variability of the Martian climate in the context of understanding habitability and 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. Deep Space Mission Systems provides capabilities and infrastructures for tracking, navigation, and data return to Earth to support interplanetary spacecraft missions.

### OVERALL BUDGET

The FY 2006 request is \$1,900.5 million, including:

- \$858 million for Mars and lunar robotic exploration (a 17 percent increase above FY 2005), following up NASA's success with the *Spirit* and *Opportunity* rovers with the Mars Reconnaissance Orbiter, Mars Science Laboratory, Lunar Reconnaissance Orbiter, and the competition for Phoenix, a new mission to look for complex organic chemicals.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- Launch the first New Frontiers mission, to Pluto and the Kuiper Belt in January 2006.
- Insert the Mars Reconnaissance Orbiter into orbit around Mars and begin science investigations.
- Achieve a major MESSENGER Discovery mission milestone with the flyby of Venus (on the way to Mercury).
- Return the Stardust Discovery mission science samples to Earth in January 2006.
- Launch the Dawn Discovery mission by July 2006.

## 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. Through the Universe Theme, NASA seeks to understand these cycles and how they created the unique conditions that support life. 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 around nearby stars.



## NASA FY 2006 Budget Request Summary

The Universe suite of operating missions includes three Great Observatories which have helped astronomers unravel the mysteries of the cosmos: the Hubble Space Telescope, which has literally rewritten astronomy textbooks since its launch in 1990; 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, going to the edge of black holes and nearly to the beginning of time. In the search for origins, scientists will peer one-by-one at hundreds of Earth's nearest neighbor stars and inventory their planets, searching for solar systems resembling this one with a balmy, wet planet like Earth. Researchers do not yet know whether other similar worlds are common or exceedingly rare, but the journey to discovery has already begun.

### OVERALL BUDGET

The FY 2006 request is \$1,512.2 million, including:

- \$372 million to the James Webb Space Telescope (a 19 percent increase above FY 2005) for a wide array of detailed flight design and long-lead procurement and flight hardware fabrication efforts.
- \$56 million for Beyond Einstein (a 33 percent increase above FY 2005) to test and validate theories about the nature of the universe.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

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

### *Earth-Sun System Theme*



Life on Earth prospers in a climate powered by energy from the Sun that is moderated by water and carbon cycles and 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 expanding and using its 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.

## NASA FY 2006 Budget Request Summary

### OVERALL BUDGET

The FY 2006 request is \$2,063.6 million, including:

- \$243 million for Living with a Star (a 16 percent increase above FY 2005) to investigate the variability of the Sun and its impact on Earth.
- \$136 million for Earth System Science Pathfinder (a 26 percent increase above FY 2005), including CloudSat, Cloud-aerosol LIDAR and Infrared Pathfinder Satellite Observation (CALIPSO), Orbiting Carbon Observatory, Hydros, and Aquarius.
- \$845 million for Earth-Sun research (a three percent increase above FY 2005) to improve NASA's capability to predict weather, climate, natural hazards, and space weather.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- Ready Solar Dynamics Observatory and NPP for launch.
- Launch the Solar-Terrestrial Relations Observatory (STEREO).
- Retrieve/distribute scientific data from Cloudsat and CALIPSO.
- Continue development of the Orbiting Carbon Observatory and Aquarius.



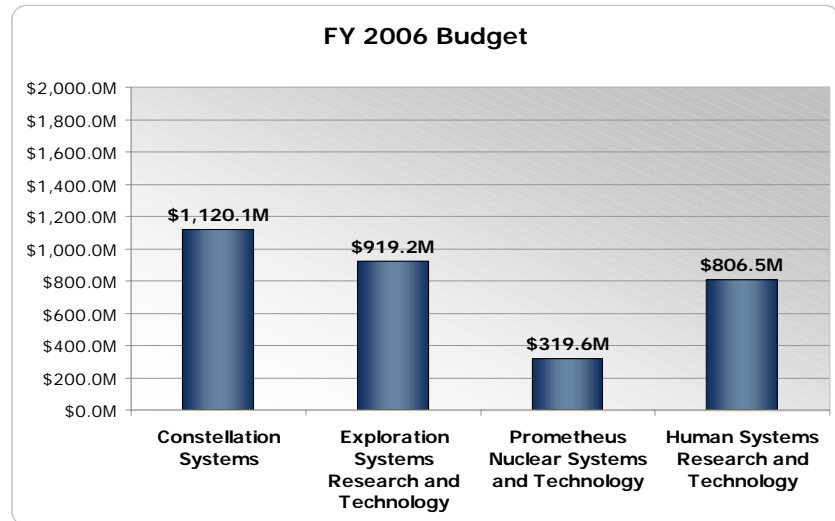
## Exploration Systems Mission Directorate



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 into ESMD. In this way, ESMD can integrate fully the broad engineering systems infrastructure

requirements and the critical human system requirements necessary for human exploration of the solar system to ensure safety, sustainability, and exploration crew effectiveness.

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



### Constellation Systems Theme



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 in which early 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 \$1,120.1 million, including:

- \$753 million for the Crew Exploration Vehicle, America's future workhorse for safe and affordable human exploration, with resources to pursue a timely flight demonstration in 2008.

## NASA FY 2006 Budget Request Summary

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

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

### ***Exploration Systems Research and Technology Theme***



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. Solar system exploration will benefit all of NASA and will be the primary focus of this Theme's activities, demanding a robust, ongoing commitment to innovation. Through such a focused research and development effort, the Theme will develop technologies that can be integrated into different spirals and different missions at appropriate times. 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 27 percent increase above FY 2005), including:

- Funding for the Advanced Space Technology and Technology Maturation programs to continue competitively awarded innovative technology development contracts to NASA Centers, industry, and academia.
- An increase of \$34 million for a newly restructured Technology Transfer Partnerships project to improve NASA's ability to both spin-out and spin-in new technologies.
- \$34 million for the Centennial Challenges program.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- Assess and address critical in-house capabilities and technology gaps.
- Issue a 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).
- Complete Phase I of Advanced Space Technology and Technology Maturation projects and initial validation of new concepts and technologies.

### ***Prometheus Nuclear Systems and Technology 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, and 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.

## NASA FY 2006 Budget Request Summary

### OVERALL BUDGET

The FY 2006 request is \$319.6 million, including:

- Funding to support the initial development of a first-ever demonstration of space-based nuclear power.
- Funding to support research and development for technologies such as advanced materials, advanced power conversion, and advanced propulsion systems that will be applicable to future missions relevant to both the science and exploration goals of the *Vision*.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- 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.
- 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.

### *Human Systems Research and Technology Theme*



The Human Systems Research and Technology (HSR&T) Theme is new to ESMD and is comprised of several initiatives formerly in the 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. The Theme now focuses on ensuring the health, safety, and security of humans throughout 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.

### OVERALL BUDGET

The FY 2006 request is \$806.5 million, including:

- Funding for three new programs that better align former research activities with present needs and improve NASA's ability to achieve the goals identified in the *Vision*. By transforming the BPRE organization and adopting a requirements-based philosophy in the redirection of its programs, NASA will be able to reprioritize International Space Station 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.
- 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.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- 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.
- Complete study and deliver report on lunar radiation protection requirements.
- Early completion of the renal stone countermeasure development project.
- Begin testing of bone and cardiovascular countermeasures in space.

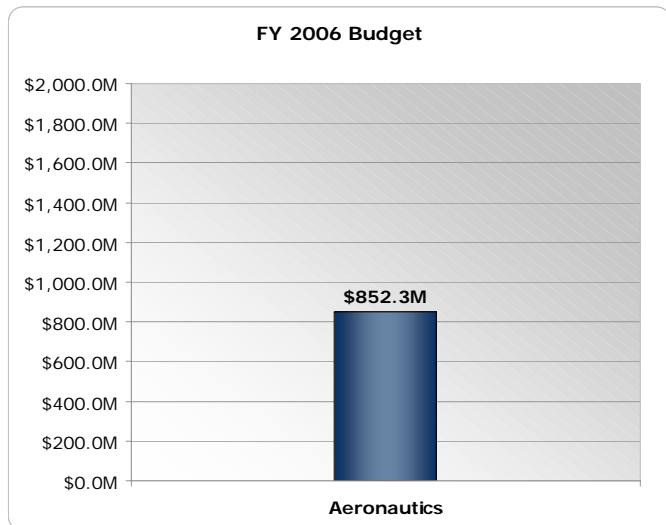
## Aeronautics Research Mission Directorate



Over the last century, aviation has evolved into an integral part of our economy, a cornerstone of national defense, and an essential component of everyday life. Aviation generates more than \$1 trillion in economic activity in the United States every year. Americans rely on aviation not just for transportation, but for recreation as well. The ability of aviation to offer safe, affordable, fast, predictable movement of goods and people has fueled the industry's growth. But, just as the Nation has become more dependent on faster and

more efficient air travel, important challenges have emerged: the need to reduce the fatal accident rate; the need to enhance post-9/11 air travel safety and security; the need to reduce air and noise pollution that restrict the number and type of aircraft operating in certain areas; and the need to improve the efficiency/capacity of the air traffic and airport systems.

The Aeronautics Research Mission Directorate (ARMD) supports NASA's mission to understand and protect Earth by playing a key role in the technology developments needed to resolve the challenges faced by the aeronautics community and create a safer, more secure, environmentally friendly, and efficient national aviation system. 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), NASA conducts research in air traffic management technologies for new automation tools and concepts operations. In collaboration with the Department of Homeland Security, NASA conducts similar research to improve the security of the National Airspace System.



### Aeronautics Technology Theme



The Aeronautics Technology Theme (AT) serves the Nation by developing technologies to improve aircraft and air transportation system safety, security, and performance; reduce aircraft noise and emissions; and increase the capacity and efficiency of the National Airspace System. AT also conducts research that will enable the use of uncrewed aerial vehicles (UAVs) for revolutionary Earth and space science missions.

AT partners with other government agencies, academia, and industry to enhance research efforts and to ensure effective development and transfer of new technologies. As part of a national effort, NASA and the FAA Joint Planning and Development Office have developed an integrated plan for the Next Generation Air Transportation System that will transform America's air transportation network by 2025.

## NASA FY 2006 Budget Request Summary

AT 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, which has been restructured to emphasize breakthrough technologies and demonstrations, works to reduce aircraft noise, support development of zero-emissions aircraft, and develop UAVs for Earth and space science missions.

### **MAJOR ACTIVITIES PLANNED FOR FY 2006:**

- Develop a modeling and simulation capability for National Airspace Systems.
- Develop strategic management tools for National Airspace System.
- Develop wake vortex operation procedures/standards to safely increase the terminal area capacity, and allow reduced separation standards for wake vortex avoidance considerations.
- Demonstrate prototype Distributed National Archives for Flight Operations Quality Assurance and Aviation Safety Action Program (ASAP) data with participation of multiple airlines

### **OVERALL BUDGET**

The FY 2006 request is \$852.3 million, including:

- \$193 million for Aviation Safety and Security (a four percent increase above FY 2005) to decrease aviation accident and fatality rates.
- \$200 million for Airspace Systems (a 32 percent increase above FY 2005) to provide technologies that can dramatically increase the capacity and mobility of the Nation's air transportation system.

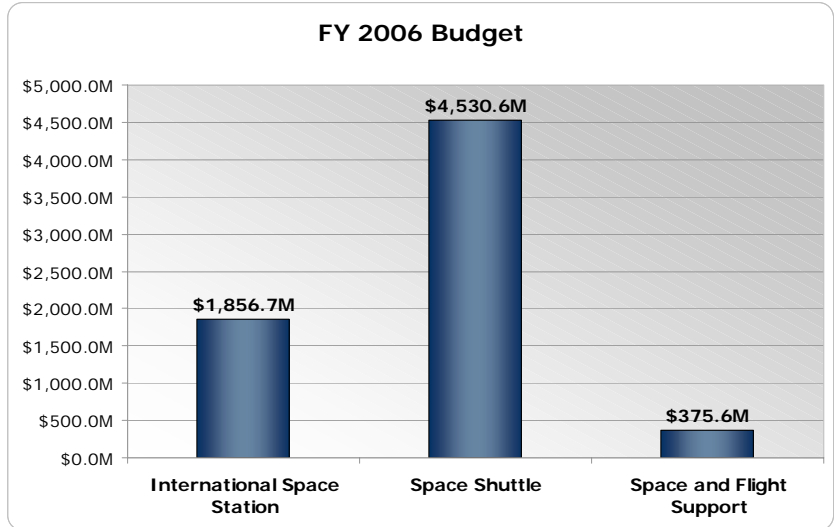


## Space Operations Mission Directorate

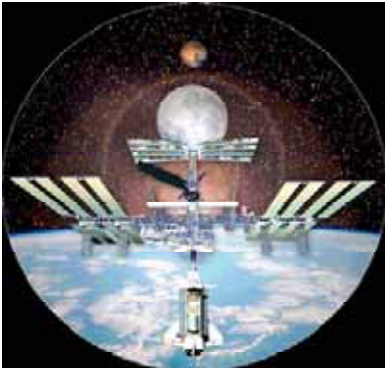


Station (ISS); and space communications systems and its supporting infrastructure. The SOMD also provides the unique human system necessary to open the space frontier as broadly as possible.

The Space Operations Mission Directorate (SOMD) programs ensure that NASA's human and robotic explorers have reliable, safe, and affordable access to space while creating new exploration and research opportunities through the extension of human presence in space. The SOMD enables NASA to achieve its goals by providing: transportation systems like the Space Shuttle; operational research facilities in space like the International Space



### International Space Station Theme



The International Space Station Theme supports the construction and operation of a research facility in low Earth orbit as one of the first steps toward achieving the *Vision for Space Exploration*. The ISS provides a unique, continuously operating research facility in which researchers can develop and test medical countermeasures and engineering solutions for long-term human space travel while providing ongoing practical experience in living and working in space. The ISS Theme also supports a variety of pure and applied research for the United States and its international partners.

ISS assembly will be completed by the end of the decade. NASA is examining configurations for the ISS that meets the needs of both the Vision for Space Exploration and Agency's international partners using as few Space Shuttle flights as possible. A key element of the ISS program is the crew and cargo services project, which will purchase services for cargo and crew transport using existing and emerging capabilities.

### OVERALL BUDGET

The FY 2006 request is \$1,856.7 million, including:

- \$1,697 million (a seven percent increase above FY 2005) for continuous on-orbit operations and assembly after the Shuttle return to flight;
- \$ 160 million for the acquisition of cargo and crew services for the acquisition of cargo and crew services to support the ISS.



## NASA FY 2006 Budget Request Summary

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- Reestablish on-orbit crew of three as early as Shuttle flight ULF1.1.
- Select commercial transportation service provider(s).
- Resume assembly of ISS.
- Maintain on-orbit operations.

### *Space Shuttle*



The Space Shuttle is currently the only launch capability owned by the United States that enables human access to space, and it is currently the only vehicle that can support assembly of the ISS. NASA will phase-out the Space Shuttle in 2010 when its role in ISS assembly is complete.

### OVERALL BUDGET:

The FY 2006 request is \$4,530.6 million. This budget will enable:

- Five Space Shuttle flights to the International Space Station to continue assemble.
- Planning for the phase-out of the Space Shuttle program in 2010, after nearly 30 years of service.

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- Ensure the proper technical integration of all Space Shuttle elements.
- Safely fly planned Space Shuttle manifest.
- Initiate early actions for an orderly phase-out of the Space Shuttle program.

### *Space and Flight Support*



This Space and Flight Support Theme encompasses Space Communications, Launch Services, Rocket Propulsion Testing, and Crew Health and Safety. Space Communications consists of: (1) the Tracking and Data Relay Satellite System (TDRSS), which supports activities such as the Space Shuttle, ISS, Expendable Launch Vehicles, and research aircraft; and (2) the NASA Integrated Services Network, which provides telecommunications services at facilities, like flight support networks, mission control centers, and science facilities, and administrative communications networks for NASA Centers. The Launch Services program focuses on meeting the Agency's launch and payload processing requirements by assuring safe and cost-effective access to space via the Space Shuttle and expendable launch vehicles. The Rocket Propulsion Testing program supports a core of highly trained rocket test and engineering crews and test facilities. Finally, the

Crew Health and Safety program provides oversight and accountability for the overall health and safety of NASA's astronaut corps.

### OVERALL BUDGET:

The FY 2006 request is \$375.6 million. The budget includes:

- \$69 million for Rocket Propulsion Testing (a five percent increase above FY 2005).
- \$9 million for Crew Health and Safety (a 25 percent increase above FY 2005).

## NASA FY 2006 Budget Request Summary

### MAJOR ACTIVITIES PLANNED FOR FY 2006:

- Participate in technology demonstration of miniature Synthetic Aperture Radar/Communication integrated payload for the Chandrayaan-1 mission.
- Evaluate concepts to support Exploration Systems Mission Directorate timelines.
- Implement the Mission Operation Voice Enhancement Upgrade Project and the Space Network Expansion Project.
- Support Space Shuttle return to flight.
- Launch six primary payloads on Expendable Launch Vehicles.

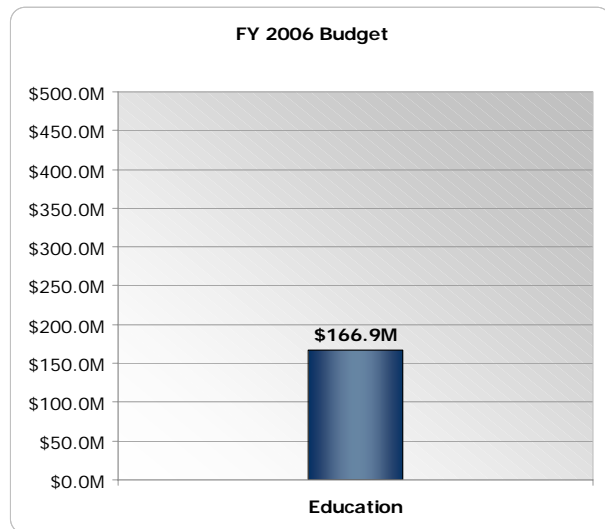
## Education



To develop the next generation of explorers, NASA must 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 images of NASA's 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 is a core part of NASA's mission, and education programs are an integral part of every major NASA activity.

NASA is working to ensure a pipeline of highly trained people prepared to meet mission requirements within NASA, as well as in industry and academia by: motivating students to pursue careers in science, technology, engineering, and mathematics; providing educators with unique teaching tools and compelling teaching experiences; ensuring that public resources are invested wisely; and fully engaging minority and under-represented students, educators, and researchers in NASA's education programs. The Office of Education will strive to reach, connect with, excite and inspire today's youth—the next generation of scientists, inventors, technicians, and explorers.



### Education Programs



The Education Programs Theme will provide unique teaching and learning experiences through the Agency's research and flight missions. Students and educators will work with NASA and university scientists using 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. To ensure diversity in NASA's future workforce, Office of Education programs will continue to pay particular attention to under-represented groups of students at all grade levels and economic

levels. And, NASA Education programs will increase support to the Nation's universities providing challenging research and internship opportunities for qualified students, as well as a roadmap for students seeking NASA careers.

## NASA FY 2006 Budget Request Summary

### OVERALL BUDGET:

The FY 2006 request is \$166.9 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 Mission Directorates in coordination with the Office of Education.

## NASA FY 2006 Budget Request Summary

### Institutional Investments

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As a function of full cost management, the following institutional investments are included in the preceding Mission Directorate budgets as either direct program charges or as Center or Corporate General and Administrative (G&A) charges. These areas are included in the summary below to document the resources provided for these activities.

#### **Center G&A**

Center G&A costs include Center security, ground maintenance, fire protection, business computing, public affairs, institutional construction of facilities, human resources, procurement, budgeting, etc. FY 2006 highlights include:

- Investing \$1.5 billion in the critical Center infrastructure required to support the *Vision for Space Exploration*.

| <b>Center</b>                 | <b>FY 2006<br/>(\$ in millions)</b> |
|-------------------------------|-------------------------------------|
| Ames Research Center          | 191                                 |
| Dryden Flight Research Center | 40                                  |
| Glenn Research Center         | 161                                 |
| Goddard Space Flight Center   | 214                                 |
| Johnson Space Center          | 207                                 |
| Kennedy Space Center          | 232                                 |
| Langley Research Center       | 195                                 |
| Marshall Space Flight Center  | 226                                 |
| Stennis Space Center          | 39                                  |
| <b>Total, Center G&amp;A</b>  | <b>1,505</b>                        |

#### **Corporate G&A**

Corporate G&A costs include Headquarters operations and Agency-wide functions. FY 2006 highlights include:

- \$882 million total for FY 2006, as shown in the table below.
- \$77 million for the Integrated Financial Management Program (IFMP) to continue improvement of NASA financial systems.
- \$70 million for the Chief Information Office to provide tools and systems for efficient operations.
- \$79 million for the NASA Engineering and Safety Center providing independent expertise to NASA's programs.
- \$69 million for Environmental Compliance and Restoration supporting NASA's stewardship of government property.

## NASA FY 2006 Budget Request Summary

| <b>Corporate G&amp;A</b>                         | <b>FY 2006<br/>(\$ in millions)</b> |
|--|-------------------------------------|
| Headquarters Corporate Activities                | 373                                 |
| NASA Engineering and Safety Center               | 79                                  |
| Corporate IFMP/HQ IFM                            | 77                                  |
| Chief Information Officer                        | 70                                  |
| Environmental Compliance and Restoration         | 69                                  |
| Chief Engineer                                   | 53                                  |
| Safety and Mission Assurance                     | 52                                  |
| Agency Operations                                | 27                                  |
| Independent Verification and Validation Facility | 27                                  |
| Advanced Planning and Integration                | 20                                  |
| Center-Based Corporate G&A                       | 11                                  |
| Corporate CoF                                    | 10                                  |
| Security Management                              | 9                                   |
| Chief Health and Medical Officer                 | 5                                   |
| <b>Total, Corporate G&amp;A</b>                  | <b>882</b>                          |

### WORKFORCE

FY 2006 highlights include:

- \$2.390 billion for salaries and benefits and \$74.9 million for travel for 18,798 full time equivalent personnel. Salaries are included in G&A or program direct costs as appropriate.

### CONSTRUCTION OF FACILITIES

FY 2006 highlights include:

\$292.7 million for Construction of Facilities (CoF);

- \$110.8 million for program direct CoF, carried in program budgets;
- \$172.9 million for non-programmatic CoF, carried within Center G&A; and
- \$9.0 million for a Facility Demolition initiative, carried within Corporate G&A, to remove unused buildings at the NASA field Centers.

### ENVIRONMENTAL COMPLIANCE AND RESTORATION

FY 2006 highlights include:













- \$69.1 million for environmental compliance, including \$9.2 million for Plum Brook cleanup.
- Effective this fiscal year, Environmental Compliance and Restoration was transferred to Corporate G&A.



**President’s Management Agenda**

In 2004, Office of Personnel Management Director Kay Coles James and Office of Management and Budget Deputy Director Clay Johnson, III, honored NASA as the first Federal agency to achieve the highest standards of excellence (“Green”) in two of the original five government-wide President’s Management Agenda (PMA) initiatives: (1) Strategic Management of Human Capital, and (2) Budget and Performance Integration. NASA also achieved “Green” in the PMA initiative of e-government. And, in December 2004, NASA was awarded a President’s Quality Award in a third initiative, Competitive Sourcing. NASA’s goal is to achieve “Green” ratings in all five PMA initiatives within three to four years. Like several other agencies, NASA also is working toward improvement in a new PMA initiative, Federal Real Property Management.

NASA’s President’s Management Agenda Scorecard (December 31, 2004)

|          | Human Capital   | Competitive Sourcing  | Financial Performance   | E- Government  | Budget and Performance Integration  | Federal Real Property Management  |
|----------|---|---|---|--|---|---|
| Status*  |    |    |    |    |    |    |
| Progress |  |  |  |  |  |  |

**Human Capital**

NASA has implemented a human capital plan, established an accountability system to track the associated results, and demonstrated the ability to make distinctions in employee performance using a comprehensive awards system. NASA also has received Office of Personnel Management provisional certification in 2004 for its Senior Executive Service and SL/ST performance appraisal system.

**Competitive Sourcing**

NASA has a competitive sourcing plan and has announced two standard competitions involving more than 230 positions. Science competitions are an integral part of this plan enabling NASA scientists to compete against those in academia, industry, and other government agencies for research opportunities.

**Financial Performance**

NASA continues to face significant challenges in improving the quality of the Agency’s financial reporting; however, NASA has an aggressive action plan and timetable to correct deficiencies. In 2003, NASA implemented the Core Financial Module of the Integrated Financial Management Program (IFMP) to standardize financial data and processes across Headquarters and the 10 NASA Centers. IFMP replaced 140 disparate legacy financial systems. Data reconciliation issues due to the conversion from the old to the new systems, however, presented challenges in preparing NASA’s FY 2003 and FY 2004 financial statements.

## NASA FY 2006 Budget Request Summary

### ***e-Government***

NASA has an information technology (IT) architecture in place to guide Agency investments and strengthen IT security. All NASA IT systems are now operating within 10 percent of planned budget and schedule. NASA is committed to implementing government-wide e-government solutions, such as the e-payroll system, which will improve the efficiency of government operations.

### ***Budget and Performance Integration***

NASA used performance information and full-cost considerations to develop the FY 2004, FY 2005, and FY 2006 budget requests and to support the Agency's management decisions. As noted, NASA was the first government agency to achieve a "Green" for this initiative.

### ***Federal Real Property Management***

NASA is an active participant on the Federal Real Property Council, which supports government-wide best practices. The Agency currently is developing a comprehensive asset management plan to guide planning, acquisition, operation, and disposal of real property.

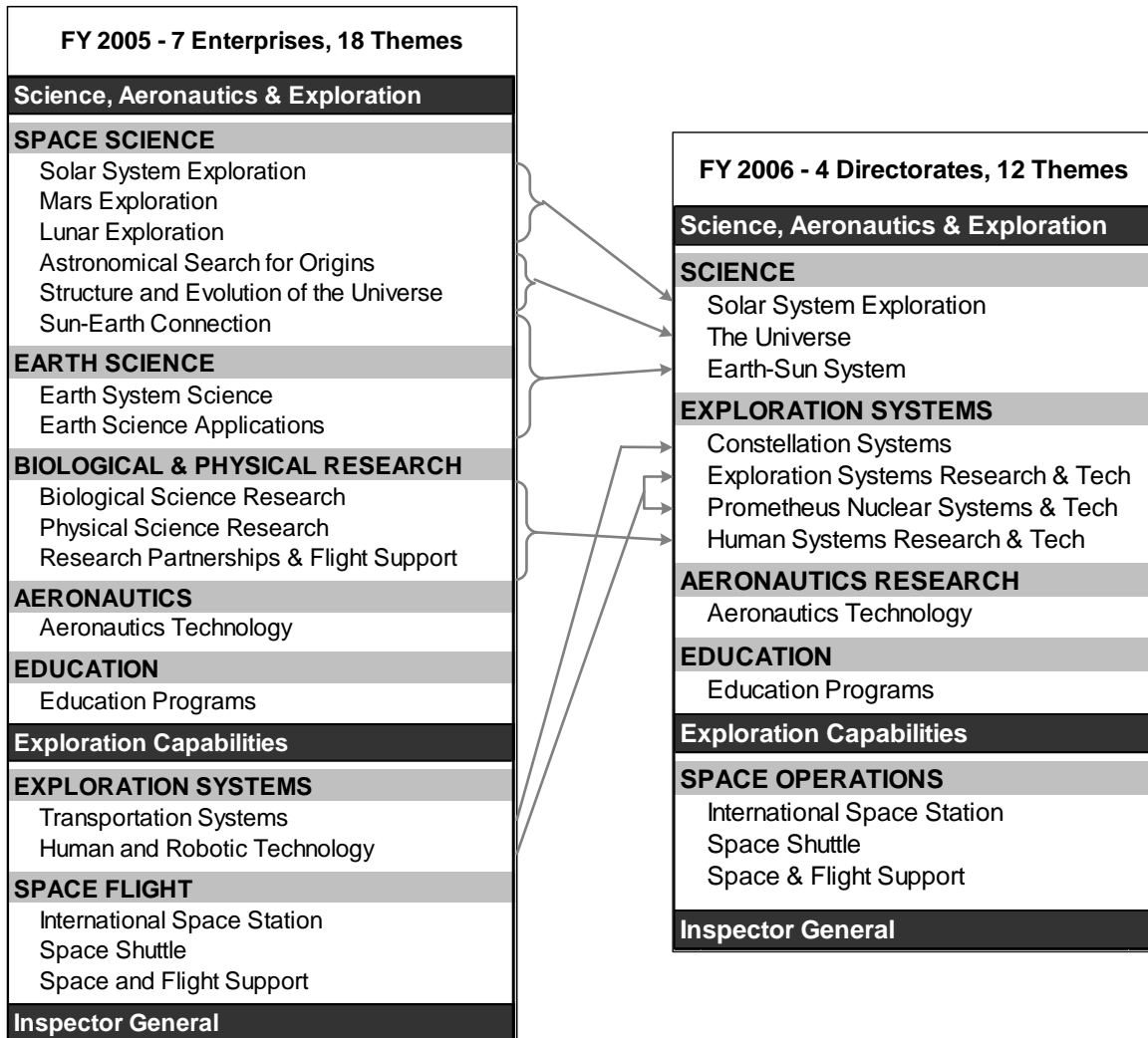
# NASA FY 2006 Budget Request Summary

## Budget Structure

NASA's budget is aggregated under three appropriation accounts: (1) Science, Aeronautics, and Exploration; (2) Exploration Capabilities; and (3) Inspector General. Under the first two accounts, the budget is organized according to Mission Directorates, NASA's primary areas of activity, and Themes, programmatic subdivisions of Mission Directorates that function as program "investment portfolios."

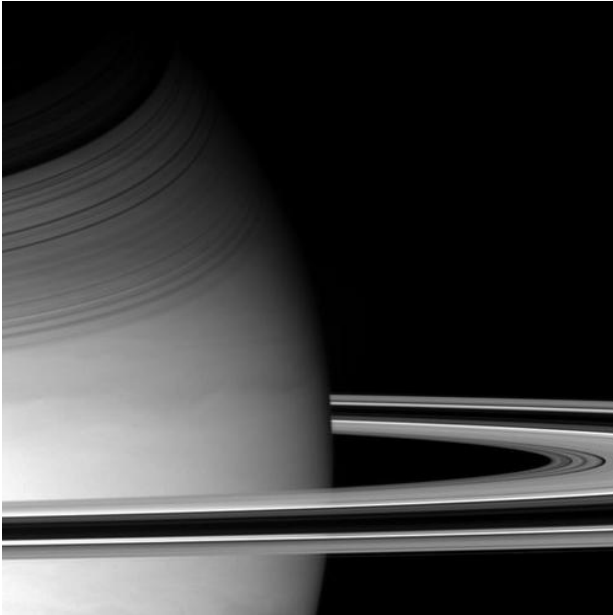
In response to the *Vision for Space Exploration*, supported by recommendations from the Aldridge Commission, NASA streamlined its budget structure from seven Enterprises with 18 Themes to four Mission Directorates and 12 Themes that align the Agency's resources with the *Vision for Space Exploration* while allowing for the flexibility NASA needs as it proceeds with the Agency's transformation. The new structure consolidates the Science Themes and more clearly delineates the Exploration Systems Themes. The Aeronautics activities are clearly defined as research, and the new structure continues to clearly identify NASA's Education activities.

Comparison of NASA's FY 2005 and FY 2006 Budget Structures



## Appropriation Summary: Science, Aeronautics and Exploration

| Millions of Dollars                         | FY 2004<br>9/28/04<br>Operating Plan | FY 2005<br>12/23/04<br>Operating Plan | FY 2006<br>Budget<br>Request |
|---|--------------------------------------|---------------------------------------|------------------------------|
| <b><u>SCIENCE</u></b>                       | <b><u>5,599.8</u></b>                | <b><u>5,527.2</u></b>                 | <b><u>5,476.3</u></b>        |
| 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                      |
| <b><u>EXPLORATION SYSTEMS</u></b>           | <b><u>2,573.7</u></b>                | <b><u>2,684.6</u></b>                 | <b><u>3,165.4</u></b>        |
| 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                        |
| <b><u>AERONAUTICS RESEARCH</u></b>          | <b><u>1,056.8</u></b>                | <b><u>906.2</u></b>                   | <b><u>852.3</u></b>          |
| Aeronautics Technology                      | 1,056.8                              | 906.2                                 | 852.3                        |
| <b><u>EDUCATION</u></b>                     | <b><u>230.4</u></b>                  | <b><u>216.7</u></b>                   | <b><u>166.9</u></b>          |
| Education Programs                          | 230.4                                | 216.7                                 | 166.9                        |
| <b><u>TOTAL APPROPRIATION</u></b>           | <b><u>9,460.7</u></b>                | <b><u>9,334.7</u></b>                 | <b><u>9,661.0</u></b>        |



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

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**Solar System Exploration**

**The Universe**

**Earth-Sun System**

# SCIENCE

## Purpose

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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    |
|---|--------------------------------|
| <b>Space Science Enterprise</b>         | 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         |
| <b>Earth Science Enterprise</b>         |                                |
| 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.

## Mission Directorate: Science

### 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**

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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.

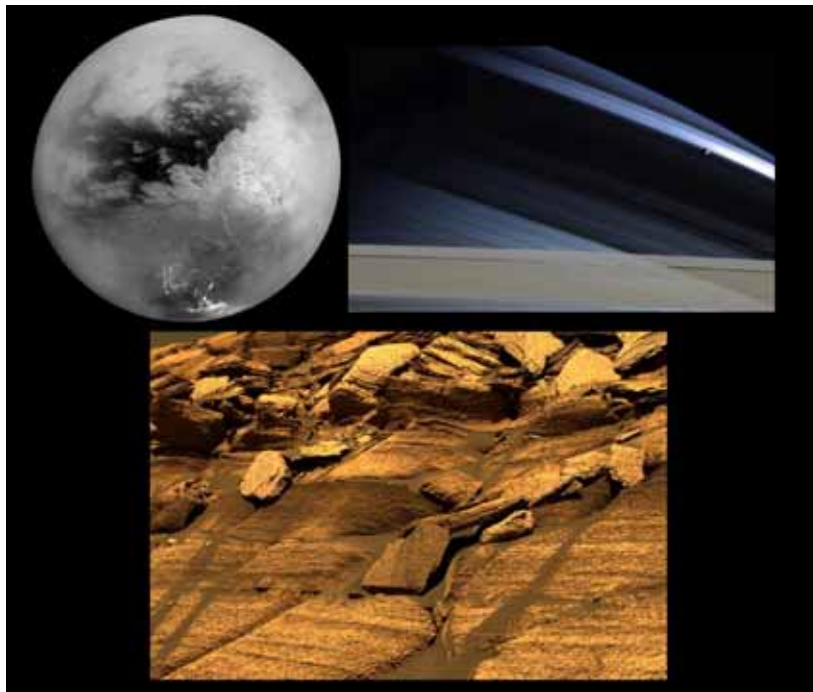
At the center of the solar system is the Sun, a magnetically variable star. This variability has impacts on life and technology that are felt here on Earth and throughout the solar system. NASA is working to understand this planetary system because it is the only star-planet system researchers can investigate 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.

***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.

**Performance**

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***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 successfully on January 12, 2004.
  - Solar System Exploration (SSE) selected six science instruments for the Lunar Reconnaissance Orbiter mission.
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**Solar System Exploration Theme Commitment in Support of the NASA Mission :**

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**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.



## Theme: Solar System Exploration

*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 |
|---------------------------------|----------------|----------------|-------------|----------------|----------|
| <b>Solar System Exploration</b> | <b>1,909.5</b> | <b>1,858.1</b> | <b>42.4</b> | <b>1,900.5</b> |          |
| 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) from 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)

| <u>Discovery</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

| <b>Implementation Schedule:</b>   |  |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
|---|--|----|----|----|----|----|----|--|-----------------------------------|--|----------------------------|-------------------------------------|-------------------|-------------------------------------|-------------------|------------------------------------|------------------|-------------------------------------|----------------|------------------------------------|--|
| Project   | Schedule by Fiscal Year                            |    |    |    |    |    |    | Purpose  | Phase Dates                       |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
|   | 04   | 05 | 06 | 07 | 08 | 09 | 10 |  | Beg                               | End  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <b>Stardust</b>   |  |    |    |    |    |    |    | A mission to bring samples of interstellar dust back to Earth.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Feb-99<br>Feb-99<br>Feb-99<br>Feb-99<br>Sep-06           |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <b>Genesis</b>  |  |    |    |    |    |    |    | A mission to bring samples of solar wind particles back to Earth.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Aug-01<br>Aug-01<br>Aug-01<br>Aug-01<br>Sep-08           |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <b>MESSENGER</b>  |  |    |    |    |    |    |    | A mission to Mercury to conduct an in-depth study of the Sun's closest neighbor.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Sep-00<br>Jun-01<br>Jun-01<br>Aug-04<br>Aug-04<br>Mar-12 |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <b>Deep Impact</b>  |  |    |    |    |    |    |    | A mission to study the composition of the interior of a comet.   | Tech<br>Form<br>Dev<br>Ops<br>Res | May-00<br>Mar-01<br>Jan-05<br>Jan-05<br>Mar-06           |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <b>Dawn</b>   |  |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Sep-02<br>Dec-03<br>Dec-03<br>Jun-06<br>Jul-14           |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <b>ASPERA-3</b>   |  |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Sep-02<br>Jun-03<br>Jun-03<br>Mar-07<br>Mar-07           |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <table border="0"> <tr> <td><span style="color:blue">■</span></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td><span style="color:orange">■</span></td> <td>Formulation(Form)</td> </tr> <tr> <td><span style="color:yellow">■</span></td> <td>Development (Dev)</td> </tr> <tr> <td><span style="color:green">■</span></td> <td>Operations (Ops)</td> </tr> <tr> <td><span style="color:purple">■</span></td> <td>Research (Res)</td> </tr> <tr> <td><span style="color:black">■</span></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |                                   | <span style="color:blue">■</span>                        | Tech & Adv Concepts (Tech) | <span style="color:orange">■</span> | Formulation(Form) | <span style="color:yellow">■</span> | Development (Dev) | <span style="color:green">■</span> | Operations (Ops) | <span style="color:purple">■</span> | Research (Res) | <span style="color:black">■</span> | Represents a period of no activity for the Project |
| <span style="color:blue">■</span>   | Tech & Adv Concepts (Tech)                         |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <span style="color:orange">■</span>   | Formulation(Form)                                  |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <span style="color:yellow">■</span>   | Development (Dev)                                  |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <span style="color:green">■</span>  | Operations (Ops)                                   |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <span style="color:purple">■</span>   | Research (Res)                                     |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |
| <span style="color:black">■</span>  | Represents a period of no activity for the Project |    |    |    |    |    |    |  |                                   |  |                            |                                     |                   |                                     |                   |                                    |                  |                                     |                |                                    |  |

**Theme:** Solar System Exploration

**Program:** Discovery

### **Strategy For Major Planned Acquisitions**

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- 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**

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- 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)

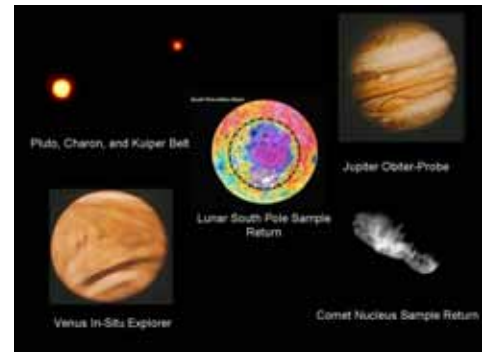
| <u>New Frontiers</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|----------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD     | 147.5         | 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.

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.



Science targets for New Frontiers Program

<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)

| <u>Technology</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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.



Collection of current technology investment

**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.
- Radioisotope 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.

| <b>Implementation Schedule:</b>    |                         |    |    |    |    |    |    |  |             |        |        |
|------------------------------------|-------------------------|----|----|----|----|----|----|--|-------------|--------|--------|
| 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        | Oct-03 | Sep-50 |
|                                    |                         |    |    |    |    |    |    |  | Form        |        |        |
|                                    |                         |    |    |    |    |    |    |  | Dev         |        |        |
|                                    |                         |    |    |    |    |    |    |  | Ops         |        |        |
|                                    |                         |    |    |    |    |    |    |  | Res         |        |        |
| 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        | Oct-02 | Sep-50 |
|                                    |                         |    |    |    |    |    |    |  | Form        |        |        |
|                                    |                         |    |    |    |    |    |    |  | Dev         |        |        |
|                                    |                         |    |    |    |    |    |    |  | Ops         |        |        |
|                                    |                         |    |    |    |    |    |    |  | Res         |        |        |
|                                    |                         |    |    |    |    |    |    |  |             |        |        |

**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.

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

| <u>Deep Space Mission Systems (DSMS)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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/>



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).

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

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## 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.

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## Changes From FY 2005

- There are no changes.

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## Program Management

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

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## 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.

**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<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Sep-10 |
| Deep Space Network                      |                         |    |    |    |    |    |    | Acquire telemetry data from spacecraft and transmit commands to spacecraft.                            | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Sep-10 |
| Optical Long-term Tech                  |                         |    |    |    |    |    |    | Provide technical guidance and development of components for future deep space optical communications. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Sep-10 |
|   |                         |    |    |    |    |    |    |  |                                   |               |

**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)

| <u>Solar System Research</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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.



Cassini image of 6-Phoebe

**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), Rosetta (ESA Comet rendezvous mission), and Hayabusa/Muses-C (JAXA asteroid sample return mission) are included within the Research Program.

| <b>Implementation Schedule:</b>   |  |    |    |    |    |    |    |  |             |        |                            |  |                   |  |                   |  |                  |  |                |  |  |
|---|--|----|----|----|----|----|----|--|-------------|--------|----------------------------|--|-------------------|--|-------------------|--|------------------|--|----------------|--|--|
| Project   | Schedule by Fiscal Year                            |    |    |    |    |    |    | Purpose  | Phase Dates |        |                            |  |                   |  |                   |  |                  |  |                |  |  |
|   | 04   | 05 | 06 | 07 | 08 | 09 | 10 |  | Beg         | End    |                            |  |                   |  |                   |  |                  |  |                |  |  |
| Cassini   |  |    |    |    |    |    |    | A mission to Saturn and its 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                     |  |                   |  |                   |  |                  |  |                |  |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation(Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |             |        | Tech & Adv Concepts (Tech) |  | Formulation(Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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).

| <b>Implementation Schedule:</b>   |                         |    |    |    |    |    |    |  |                                   |  |
|-----------------------------------|-------------------------|----|----|----|----|----|----|--|-----------------------------------|--|
| 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<br>Form<br>Dev<br>Ops<br>Res | Nov-96<br>Nov-96 Sep-06<br>Sep-97 Sep-06                         |
| Odyssey                           |                         |    |    |    |    |    |    | To study the geology, geophysics and climate of Mars.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Apr-01<br>Apr-01 Mar-07<br>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<br>Form<br>Dev<br>Ops<br>Res | May-00 Jul-00<br>Jul-00 Jul-03<br>Jul-03 Mar-05<br>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<br>Form<br>Dev<br>Ops<br>Res | Jan-01 Jul-02<br>Jan-02 Aug-05<br>Aug-05 Dec-10<br>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<br>Form<br>Dev<br>Ops<br>Res | Jan-00 Sep-00<br>Sep-00 Jun-03<br>Jun-03 Dec-05<br>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<br>Form<br>Dev<br>Ops<br>Res | Nov-03 Aug-05<br>Aug-05 Nov-09<br>Nov-09 Oct-12<br>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<br>Form<br>Dev<br>Ops<br>Res | Aug-03 Mar-05<br>Mar-05 Aug-07<br>Aug-07 Oct-08<br>May-08 Oct-09 |
|                                   |                         |    |    |    |    |    |    |  |                                   |  |

**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.

**Theme:** Solar System Exploration

**Program:** Mars Exploration

### **Key Participants**

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- 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 Thermoelectric Generators

### **Risk Management**

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- **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.

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

| <u>Robotic Lunar Exploration</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|----------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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.gov>

**Plans For FY 2006**

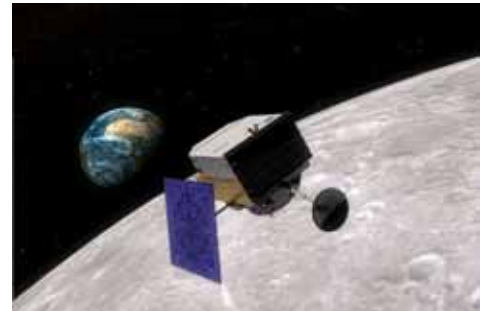
The Lunar Reconnaissance Orbiter (LRO) is the only Robotic Lunar Exploration program project in formulation. Other missions for the Robotic Lunar exploration program are in pre-formulation.

**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.



LRO spacecraft and payload - artist's Conception

**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  |                         |    |    |    |    |    |    |         |             |     |
| <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #0070C0; border: 1px solid black;"></span> Tech &amp; Adv Concepts (Tech)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #804020; border: 1px solid black;"></span> Formulation(Form)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #FFD700; border: 1px solid black;"></span> Development (Dev)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #4CAF50; border: 1px solid black;"></span> Operations (Ops)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #9C27B0; border: 1px solid black;"></span> Research (Res)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: black; border: 1px solid black;"></span> Represents a period of no activity for the Project</li> </ul> |                         |    |    |    |    |    |    |         |             |     |

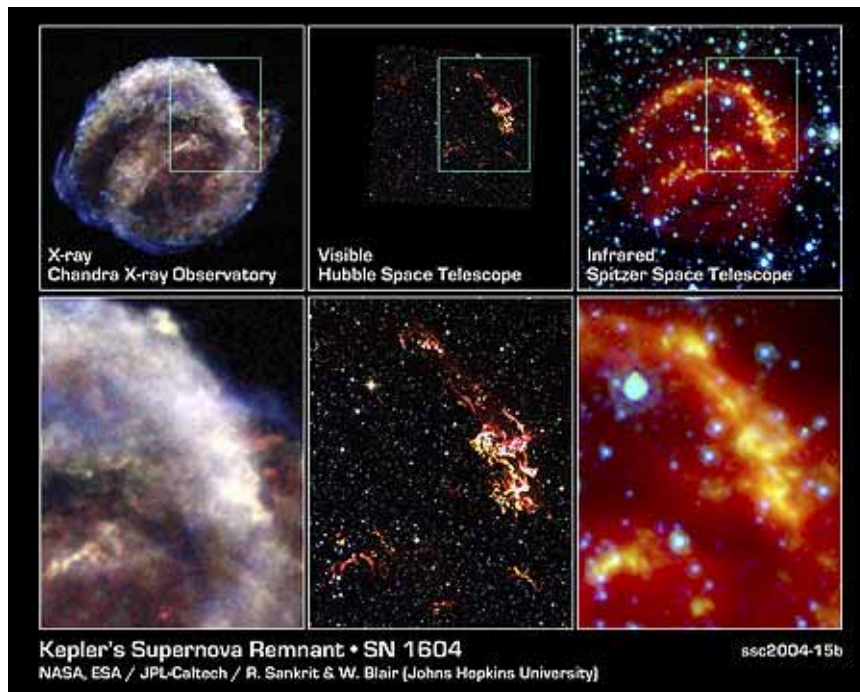
**Strategy For Major Planned Acquisitions**

- 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.

# 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.

**Relevance:** *Why* NASA conducts The Universe work

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***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**

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***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.

**The Universe Theme Commitment in Support of the NASA Mission :**

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**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.



**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.

## Theme: The Universe

### 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

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

### Quality

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#### **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 will 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 |
|--|----------------|----------------|-------------|----------------|----------|
| <b>The Universe</b>                              | <b>1,351.7</b> | <b>1,513.2</b> | <b>-1.0</b> | <b>1,512.2</b> |          |
| 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.

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

| <u>Navigator</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD | 165.2         | 233.7         | 199.4         | 246.6         | 394.5         | 432.1         | 434.1         |

**Overview**

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.



Missions in the Navigator program.

**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.

| <b>Implementation Schedule:</b>  |  |    |    |    |    |    |    |   |                                   |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
|--|--|----|----|----|----|----|----|---|-----------------------------------|---|----------------------------|---|--------------------|---|-------------------|---|------------------|---|----------------|---|--|
| 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 capabilities using 2 large telescopes will be developed and tested through 2007. Outrigger telescopes come on line in 2012. | Tech<br>Form<br>Dev<br>Ops<br>Res | Feb-03 Feb-23   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| Large Binocular Telescope Interferometer   |  |    |    |    |    |    |    | Development, Operations, and Research dates determined at Confirmation Review.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Jan-01 Nov-02<br>Nov-02 Mar-06<br>Mar-06 Mar-16<br>Mar-07 Mar-17                    |                            |   |                    |   |                   |   |                  |   |                |   |  |
| Space Interferometry Mission   |  |    |    |    |    |    |    | Development, Operations, and Research dates will be determined at Non Advocate Review.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-98 Aug-03<br>Aug-03 May-07<br>May-07 Oct-12<br>Oct-12 Oct-16<br>Oct-12 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<br>Form<br>Dev<br>Ops<br>Res | Oct-02 Oct-10   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |                                   |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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.

**Theme:** The Universe

**Program:** Navigator

### **Key Participants**

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- 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**

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- **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).

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

| <u>James Webb Space Telescope</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-----------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.



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.

Artist's impression of JWST

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.



**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<br>Form<br>Dev<br>Ops<br>Res | Apr-96<br>Apr-99<br>Aug-06<br>Aug-11<br>Mar-12 | Apr-99<br>Jul-06<br>Aug-11<br>Feb-17<br>Feb-18 |
|         |                         |    |    |    |    |    |    |  |                                   |  |  |

**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.

**Theme:** The Universe

**Program:** James Webb Space Telescope

### **Risk Management**

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- **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.

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

| <u>Hubble Space Telescope</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 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.

Hubble Space Telescope in Space

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.

**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.

| <b>Implementation Schedule:</b>   |  |    |    |    |    |    |    |  |                                   |   |                            |   |                    |   |                   |  |                  |   |                |   |  |
|---|--|----|----|----|----|----|----|--|-----------------------------------|---|----------------------------|---|--------------------|---|-------------------|--|------------------|---|----------------|---|--|
| 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<br>Form<br>Dev<br>Ops<br>Res | Apr-90 Sep-10<br>Apr-90 Sep-12  |                            |   |                    |   |                   |  |                  |   |                |   |  |
| HST Deorbit   |  |    |    |    |    |    |    | Schedule to be determined in greater detail during 2005.   | Tech<br>Form<br>Dev<br>Ops<br>Res |   |                            |   |                    |   |                   |  |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |                                   |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|    | 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)

| <u>Stratospheric Observatory for Infrared Astronomy (SOFIA)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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)

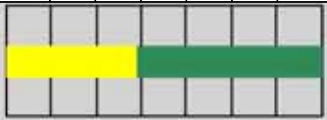
### Program Management

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     | Mar-96      | Aug-06 |
|         |   |    |    |    |    |    |    | Ops     | Sep-06      | Oct-21 |
|         |   |    |    |    |    |    |    | Res     | Sep-06      | Oct-21 |

**Legend:**

- 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)

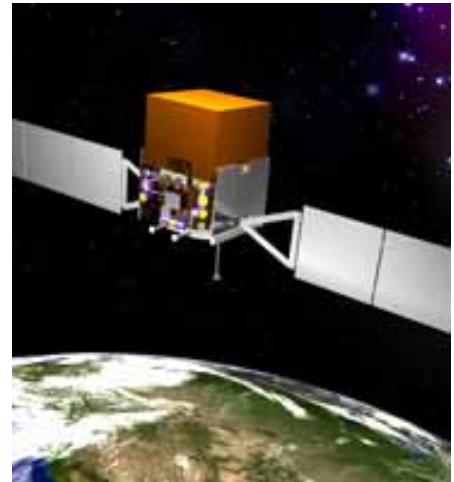
**President's FY 2006 Budget Request** (Dollars in Millions)

| <u>Gamma-ray Large Area Space Telescope (GLAST)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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.



Artist's conception of the GLAST observatory.

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.

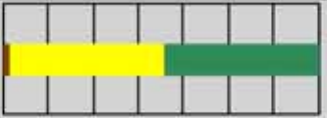


**Theme:** The Universe

**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.

| <b>Implementation Schedule:</b> |   |    |    |    |    |    |    |  |             |        |        |
|---------------------------------|---|----|----|----|----|----|----|--|-------------|--------|--------|
| 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 |        |
|                                 |   |    |    |    |    |    |    |  |             |        |        |

**Legend:**

- 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.

**Theme:** The Universe

**Program:** Gamma-ray Large Area Space Telescope (GLAST)

### **Risk Management**

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- **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)

| <u>Discovery</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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.



Artist's impression of Discovery mission focus

**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.

**Theme:** The Universe

**Program:** Discovery

### **Strategy For Major Planned Acquisitions**

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- 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)

| <u>Explorer</u>  | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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>



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

**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, electronics 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

| <b>Implementation Schedule:</b> |                         |    |    |    |    |    |    |  |               |     |
|---------------------------------|-------------------------|----|----|----|----|----|----|--|---------------|-----|
| 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  | Feb-01 Feb-05 |     |
|                                 |                         |    |    |    |    |    |    | Ops  | Feb-05 Jan-07 |     |
|                                 |                         |    |    |    |    |    |    | Res  |               |     |
| WISE                            |                         |    |    |    |    |    |    | Map sky in infrared light.   | Tech          |     |
|                                 |                         |    |    |    |    |    |    | Form   | Apr-02 Jul-05 |     |
|                                 |                         |    |    |    |    |    |    | Dev  | Jul-05 Aug-08 |     |
|                                 |                         |    |    |    |    |    |    | Ops  | Aug-08 Jul-10 |     |
|                                 |                         |    |    |    |    |    |    | 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

- 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.

**Theme:** The Universe

**Program:** Explorer

### **Risk Management**

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- **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.



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

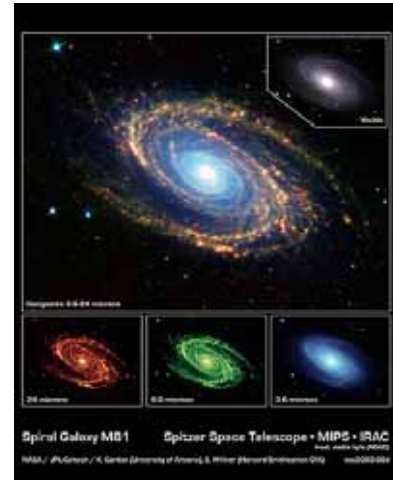
| <u>Universe Research</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD         | 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?

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>



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

**Plans For FY 2006**

The Universe Research Program will continue to maintain and provide mission 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.

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### **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.

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### **Program Management**

GSFC, JPL and MSFC - project management of current missions.

HQ and Center Program Management Councils - program responsibility.

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### **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.

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

|                                     |  |
|-------------------------------------|--|
| <span style="color:blue">■</span>   | Tech & Adv Concepts (Tech)                         |
| <span style="color:orange">■</span> | Formulation(Form)                                  |
| <span style="color:yellow">■</span> | Development (Dev)                                  |
| <span style="color:green">■</span>  | Operations (Ops)                                   |
| <span style="color:purple">■</span> | Research (Res)                                     |
| <span style="color:black">■</span>  | 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  | May-05      | Sep-08 |  |
|          |   |    |    |    |    |    |    | Res  | Dec-05      | Sep-09 |  |
|          | <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #00B0F0; border: 1px solid black;"></span> Tech &amp; Adv Concepts (Tech)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #8B4513; border: 1px solid black;"></span> Formulation (Form)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #FFFF00; border: 1px solid black;"></span> Development (Dev)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #008000; border: 1px solid black;"></span> Operations (Ops)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #800080; border: 1px solid black;"></span> Research (Res)</li> <li><span style="display: inline-block; width: 15px; height: 10px; background-color: #000000; border: 1px solid black;"></span> Represents a period of no activity for the Project</li> </ul> |    |    |    |    |    |    |  |             |        |  |

**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)

| <u>International Space Science Collaboration</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 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.



Herschel's Primary Mirror

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 anisotropies in CMB radiation field.

| <b>Implementation Schedule:</b>  |  |    |    |    |    |    |    |   |             |               |                            |  |                    |  |                   |  |                  |  |                |  |  |
|--|--|----|----|----|----|----|----|---|-------------|---------------|----------------------------|--|--------------------|--|-------------------|--|------------------|--|----------------|--|--|
| 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 |                            |  |                    |  |                   |  |                  |  |                |  |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |             |               | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|  | 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.

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

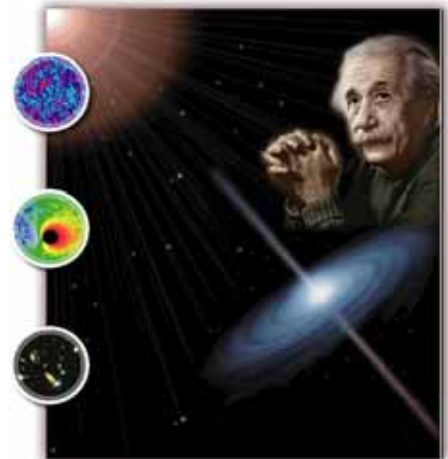
| Beyond Einstein  | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD | 26.9   | 41.8   | 55.5   | 83.9   | 164.5  | 219.6  | 247.4  |

**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.

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>



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



## Plans For FY 2006

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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 Millennium 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

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- 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

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

## Technical Description

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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.

**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        | Oct-00 | Sep-04 |
|  |                         |    |    |    |    |    |    |  | Form        | Oct-04 | Mar-09 |
|  |                         |    |    |    |    |    |    |  | Dev         | Mar-09 | Sep-13 |
|  |                         |    |    |    |    |    |    |  | Ops         |        |        |
|  |                         |    |    |    |    |    |    |  | Res         |        |        |
| 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        | Oct-00 | Oct-06 |
|  |                         |    |    |    |    |    |    |  | Form        | Oct-06 | Oct-11 |
|  |                         |    |    |    |    |    |    |  | Dev         |        |        |
|  |                         |    |    |    |    |    |    |  | Ops         |        |        |
|  |                         |    |    |    |    |    |    |  | Res         |        |        |
| <p> </p> <ul style="list-style-type: none"> <li><span style="color: blue;">■</span> Tech &amp; Adv Concepts (Tech)</li> <li><span style="color: brown;">■</span> Formulation(Form)</li> <li><span style="color: yellow;">■</span> Development (Dev)</li> <li><span style="color: green;">■</span> Operations (Ops)</li> <li><span style="color: purple;">■</span> Research (Res)</li> <li><span style="color: black;">■</span> Represents a period of no activity for the Project</li> </ul> |                         |    |    |    |    |    |    |  |             |        |        |

**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.

# 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.

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

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***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**

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***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.
-

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

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**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.

**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 |
|---|----------------|----------------|--------------|----------------|----------|
| <b>Earth-Sun System</b>                   | <b>2,338.6</b> | <b>2,155.8</b> | <b>-92.3</b> | <b>2,063.6</b> |          |
| 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.

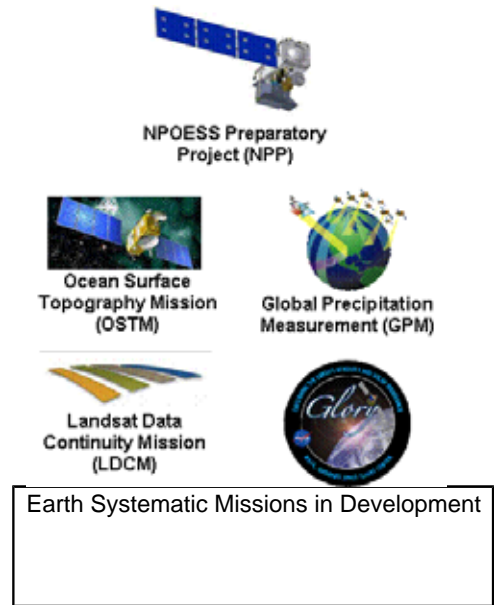


**President's FY 2006 Budget Request** (Dollars in Millions)

| 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.



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.



**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

| <b>Implementation Schedule:</b> |                         |    |    |    |    |    |    |  |                                   |                                      |                            |
|---------------------------------|-------------------------|----|----|----|----|----|----|--|-----------------------------------|--------------------------------------|----------------------------|
| 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<br>Form<br>Dev<br>Ops<br>Res | Mar-00<br>Nov-06                     | Oct-06<br>Nov-11           |
| GPM                             |                         |    |    |    |    |    |    | Build upon the Tropical Rainfall Measuring Mission (TRMM) to initiate the measurement of global precipitation, a key climate factor.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Feb-06<br>Jul-10           | Jan-06<br>Jun-10<br>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<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Apr-05<br>Apr-08<br>Apr-08 | Apr-05<br>Apr-08<br>Apr-11 |
| Glory                           |                         |    |    |    |    |    |    | Provide measurements that are critical in studies to understand the Sun, its direct and indirect effect on the Earth system, and its influence on humankind.                             | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03<br>Jun-05                     | May-05<br>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<br>Form<br>Dev<br>Ops<br>Res | Apr-02<br>Feb-06                     | Jul-06<br>Dec-08           |
|                                 |                         |    |    |    |    |    |    |  |                                   |                                      |                            |

### **Strategy For Major Planned Acquisitions**

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- 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**

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- 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**

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- **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)

| <u>Living with a Star</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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        | Aug-02 Jul-04 |
|         |                         |    |    |    |    |    |    |                                       | Dev         | Jul-04 Apr-08 |
|         |                         |    |    |    |    |    |    |                                       | Ops         | May-08 Jul-13 |
|         |                         |    |    |    |    |    |    |                                       | 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**

- 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**

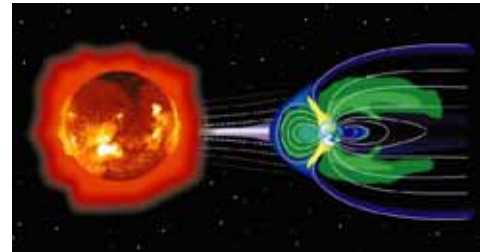
- RISK: Non-NASA organizations providing components late to LWS project causing schedule delays and cost increases. MITIGATION: Finalize inter-agency agreements that establish overall policy and commitments for each partnership.

**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**

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.



Sun-Earth Connection

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.

**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        | Nov-99 Feb-02 |
|   |                         |    |    |    |    |    |    |   | Dev         | Mar-02 Feb-06 |
|   |                         |    |    |    |    |    |    |   | Ops         | Mar-06 Mar-09 |
|   |                         |    |    |    |    |    |    |   | Res         |               |
| Solar-B   |                         |    |    |    |    |    |    | Measure the Sun's magnetic field and ultraviolet/x-ray radiation. | Tech        |               |
|   |                         |    |    |    |    |    |    |   | Form        | Dec-98 Nov-00 |
|   |                         |    |    |    |    |    |    |   | Dev         | Nov-00 Sep-06 |
|   |                         |    |    |    |    |    |    |   | Ops         | Oct-06 Oct-10 |
|   |                         |    |    |    |    |    |    |   | Res         |               |
| <p> <span style="color:blue">■</span> Tech &amp; Adv Concepts (Tech)<br/> <span style="color:orange">■</span> Formulation(Form)<br/> <span style="color:yellow">■</span> Development (Dev)<br/> <span style="color:green">■</span> Operations (Ops)<br/> <span style="color:purple">■</span> Research (Res)<br/> <span style="color:black">■</span> Represents a period of no activity for the Project </p> |                         |    |    |    |    |    |    |   |             |               |

**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)

| <u>Explorer Program</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 Interactions 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

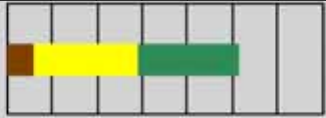
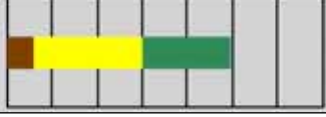


















**Program Management**

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

**Technical Description**

The Explorer program will launch MDEX 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; MDEX, 40 months.

**Implementation Schedule:**

| Project  | Schedule by Fiscal Year  |    |    |    |    |    |    | Purpose  | Phase Dates  |   |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
|--|--|----|----|----|----|----|----|--|--|---|---|----------------------------|---|--------------------|---|-------------------|---|------------------|---|----------------|---|--|
|  | 04   | 05 | 06 | 07 | 08 | 09 | 10 |  | Beg  | End   |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>THEMIS</b>  |   |    |    |    |    |    |    | Understand of the onset and evolution of magnetospheric substorms.   | <b>Tech</b><br><b>Form</b><br><b>Dev</b><br><b>Ops</b><br><b>Res</b> | Apr-02 Apr-04<br>Apr-04 Aug-06<br>Sep-06 Oct-08 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>AIM</b>   |  |    |    |    |    |    |    | 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. | <b>Tech</b><br><b>Form</b><br><b>Dev</b><br><b>Ops</b><br><b>Res</b> | Jul-02 Apr-04<br>Apr-04 Sep-06<br>Oct-06 Aug-08 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |  |   |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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.

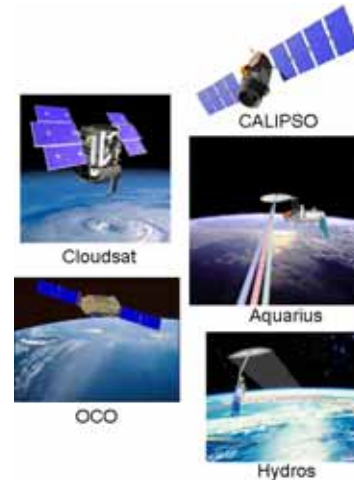


**President's FY 2006 Budget Request** (Dollars in Millions)

| 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

**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.

| <b>Implementation Schedule:</b> |                         |    |    |    |    |    |   |             |        |        |     |
|---------------------------------|-------------------------|----|----|----|----|----|---|-------------|--------|--------|-----|
| 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        | Sep-98 | Sep-02 |     |
|                                 |                         |    |    |    |    |    |   | Dev         | Oct-02 | May-05 |     |
|                                 |                         |    |    |    |    |    |   | Ops         | May-05 | Mar-07 |     |
|                                 |                         |    |    |    |    |    |   | Res         |        |        |     |
| Calipso                         |                         |    |    |    |    |    | Address the role of clouds and aerosols in Earth's atmosphere.  | Tech        |        |        |     |
|                                 |                         |    |    |    |    |    |   | Form        | Jan-98 | Dec-02 |     |
|                                 |                         |    |    |    |    |    |   | Dev         | Jan-03 | May-05 |     |
|                                 |                         |    |    |    |    |    |   | Ops         | May-05 | May-08 |     |
|                                 |                         |    |    |    |    |    |   | Res         |        |        |     |
| OCO                             |                         |    |    |    |    |    | Improve understanding of atmospheric carbon dioxide sources and sinks, a critical element in making more reliable climate predictions.                      | Tech        |        |        |     |
|                                 |                         |    |    |    |    |    |   | Form        | Oct-03 | Apr-05 |     |
|                                 |                         |    |    |    |    |    |   | Dev         | May-05 | Oct-07 |     |
|                                 |                         |    |    |    |    |    |   | Ops         | Nov-07 | Nov-09 |     |
|                                 |                         |    |    |    |    |    |   | Res         |        |        |     |
| 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        | Oct-03 | May-05 |     |
|                                 |                         |    |    |    |    |    |   | Dev         | Jun-05 | Sep-08 |     |
|                                 |                         |    |    |    |    |    |   | Ops         | Oct-08 | Oct-11 |     |
|                                 |                         |    |    |    |    |    |   | Res         |        |        |     |
| Hydros                          |                         |    |    |    |    |    | Introduce improved capability to predict costly natural hazards, such as extreme weather, floods, and droughts.   | Tech        |        |        |     |
|                                 |                         |    |    |    |    |    |   | Form        | Oct-03 | Jul-07 |     |
|                                 |                         |    |    |    |    |    |   | Dev         | Aug-07 | Dec-10 |     |
|                                 |                         |    |    |    |    |    |   | Ops         | Jan-11 | Jan-13 |     |
|                                 |                         |    |    |    |    |    |   | Res         |        |        |     |
|                                 |                         |    |    |    |    |    |   |             |        |        |     |

**Strategy For Major Planned Acquisitions**

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

**Theme:** Earth-Sun System

**Program:** Earth System Science Pathfinder

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### **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

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### **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)

| <u>Earth-Sun System Multi-Mission Operations</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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



Multi-Mission Operations

**Theme:** Earth-Sun System

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

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### **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.

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### **Program Management**

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

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### **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 | [Gantt chart showing activity from 2004 to 2010] |    |    |    |    |    |    | Continued operation of spacecraft, launch platforms, and aircraft     | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 | Oct-10 |
| EOSDIS                   | [Gantt chart showing activity from 2004 to 2010] |    |    |    |    |    |    | Acquisition, Process, archive, and distribution of Earth science data | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 | Oct-10 |
| Ground Network           | [Gantt chart showing activity from 2004 to 2010] |    |    |    |    |    |    | Operation of ground network system                                    | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 | Oct-10 |
| Alaska SAR Facility      | [Gantt chart showing activity from 2004 to 2010] |    |    |    |    |    |    | Operation of Alaska SAR facility                                      | Tech<br>Form<br>Dev<br>Ops<br>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)

| <u>Earth-Sun Research</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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



Earth's Climate Mappings

**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.

| <b>Implementation Schedule:</b>   |  |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |
|---|--|----|----|----|----|----|----|---|-------------|------|-----|----------------------------|-----|-------------------|--------|-------------------|--|------------------|--|----------------|--|--|
| 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 |                   |  |                  |  |                |  |  |
| <table style="width: 100%; border: none;"> <tr> <td style="width: 15px; background-color: #00b0f0;"></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td style="width: 15px; background-color: #800000;"></td> <td>Formulation(Form)</td> </tr> <tr> <td style="width: 15px; background-color: #ffff00;"></td> <td>Development (Dev)</td> </tr> <tr> <td style="width: 15px; background-color: #008000;"></td> <td>Operations (Ops)</td> </tr> <tr> <td style="width: 15px; background-color: #800080;"></td> <td>Research (Res)</td> </tr> <tr> <td style="width: 15px; background-color: black;"></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |             |      |     | Tech & Adv Concepts (Tech) |     | Formulation(Form) |        | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | Tech & Adv Concepts (Tech)                         |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |
|   | Formulation(Form)                                  |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |
|   | Development (Dev)                                  |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |
|   | Operations (Ops)                                   |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |
|   | Research (Res)                                     |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |
|   | Represents a period of no activity for the Project |    |    |    |    |    |    |   |             |      |     |                            |     |                   |        |                   |  |                  |  |                |  |  |



**Theme:** Earth-Sun System

**Program:** Earth-Sun Research

### **Strategy For Major Planned Acquisitions**

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- 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**

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- 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

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### **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.

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### **Program Management**

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

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### **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 |  | Tech        | Form | Dev | Ops | Res | Beg    | End    |
| <b>Agricultural Efficiency</b> |                         |    |    |    |    |    |    | 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 |
| <b>Air Quality</b>             |                         |    |    |    |    |    |    | 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 |
| <b>Aviation</b>                |                         |    |    |    |    |    |    | 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 |
| <b>Carbon Management</b>       |                         |    |    |    |    |    |    | 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 |
| <b>Coastal Management</b>      |                         |    |    |    |    |    |    | 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 |        |        |
| <b>Disaster Management</b>     |                         |    |    |    |    |    |    | 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 |
| <b>Ecological Forecasting</b>  |                         |    |    |    |    |    |    | 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 |
| <b>Energy Management</b>       |                         |    |    |    |    |    |    | Evaluate capacity to assimilate NASA observations(eg CERES, SOHO, NPP) & ESMF predictions to energy DST's(DOE/NEMS, EPR). Benchmark assimilation of products in DST (RETScreen,HOMER,NSRDB). | Tech        | Form | Dev | Ops | Res | Oct-05 | Sep-06 |
| <b>Homeland Security</b>       |                         |    |    |    |    |    |    | Benchmark the assimilation of 2 or more ESMF predictions into DHS Interagency Modeling and Atmospheric Assessment Center (IMAAC)   | Tech        | Form | Dev | Ops | Res |        |        |
| <b>Invasive Species</b>        |                         |    |    |    |    |    |    | Verify and validate the capacity of NASA observations & ESMF predictions to serve USGS DST's.  | Tech        | Form | Dev | Ops | Res | Oct-05 | Sep-06 |
| <b>Public Health</b>           |                         |    |    |    |    |    |    | Verify and validate the capacity of NASA Earth-Sun System research results to serve NIH DST.   | Tech        | Form | Dev | Ops | Res |        |        |
| <b>Water Management</b>        |                         |    |    |    |    |    |    | 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 |

Theme: Earth-Sun System

Program: Applied Sciences

| <b>Implementation Schedule:</b>    |                         |    |    |    |    |    |    |  |             |               |
|------------------------------------|-------------------------|----|----|----|----|----|----|--|-------------|---------------|
| 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 measurements 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.

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

| <u>Education and Outreach</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.



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.

ESS Education Outreach

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/>

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### 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.

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### Changes From FY 2005

- None

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### 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.

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### Technical Description

Not applicable.

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### 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.

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### 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).

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### Risk Management

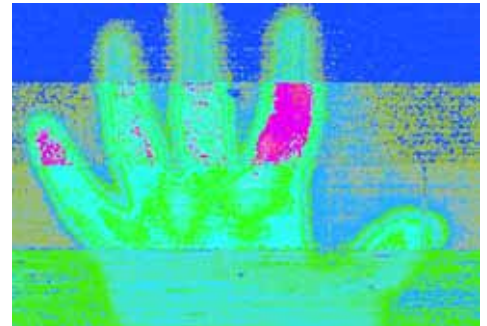
- RISK: None MITIGATION: None

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

| <u>Earth-Sun Technology</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-----------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.



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.

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

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>.



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## 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.

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## Changes From FY 2005

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

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## Program Management

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

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## 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.

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

### 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**

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- 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**

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- **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

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## Constellation Systems

## Exploration Systems Research and Technology

## Prometheus Nuclear Systems and Technology

## Human Systems Research and Technology

# EXPLORATION SYSTEMS

### Purpose

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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

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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**

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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.

## Mission Directorate: Exploration Systems

### **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

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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

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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 BPRES 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



## Mission Directorate: Exploration Systems

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.

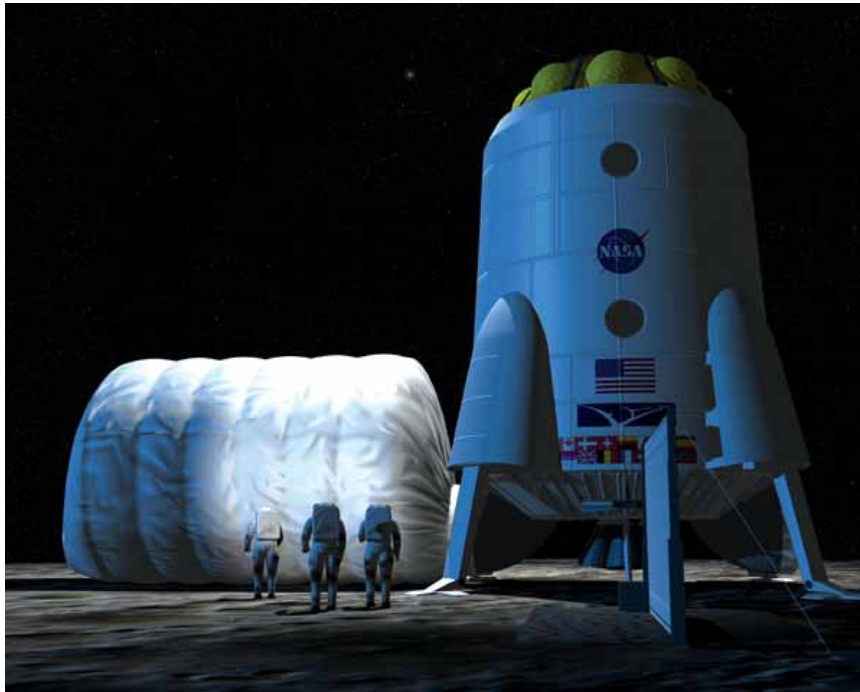
### **HUMAN HEALTH AND PERFORMANCE**

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.

# Constellation Systems



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)

| <u>Constellation Systems</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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

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***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**

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***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.
-

**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 |          |

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

| <u>Earth Orbit Capability (Spiral 1)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 implement the Vision. This program 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.

**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  |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <b>Constellation Systems Lead Systems Integrator</b>  | [Gantt chart showing activity from FY 05 to FY 08] |    |    |    |    |    |    | The Lead System Integrator is responsible for overseeing integration of all Constellation Systems into an overall System of Systems.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Jan-04<br>Sep-05<br>Oct-05<br>Dec-20                     |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <b>Crew Exploration Vehicle</b>   | [Gantt chart showing activity from FY 05 to FY 08] |    |    |    |    |    |    | The Crew Exploration Vehicle is an element of the System of Systems in which the crew is transported.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03<br>Sep-05<br>Oct-05<br>Dec-14                     |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <b>Crew Launch Vehicle</b>  | [Gantt chart showing activity from FY 05 to FY 08] |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Jan-04<br>Sep-06<br>Oct-06<br>Dec-14<br>Oct-03<br>Sep-05 |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <b>Orbital Express</b>  | [Gantt chart showing activity in FY 05]            |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-03<br>Sep-05<br>Oct-04<br>Sep-05                     |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <b>DART</b>   | [Gantt chart showing activity in FY 05]            |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-03<br>Sep-05<br>Oct-04<br>Sep-05                     |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation(Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |                                   |  |  | Tech & Adv Concepts (Tech) |  | Formulation(Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|    | 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.

**Theme:** Constellation Systems

**Program:** Earth Orbit Capability (Spiral 1)

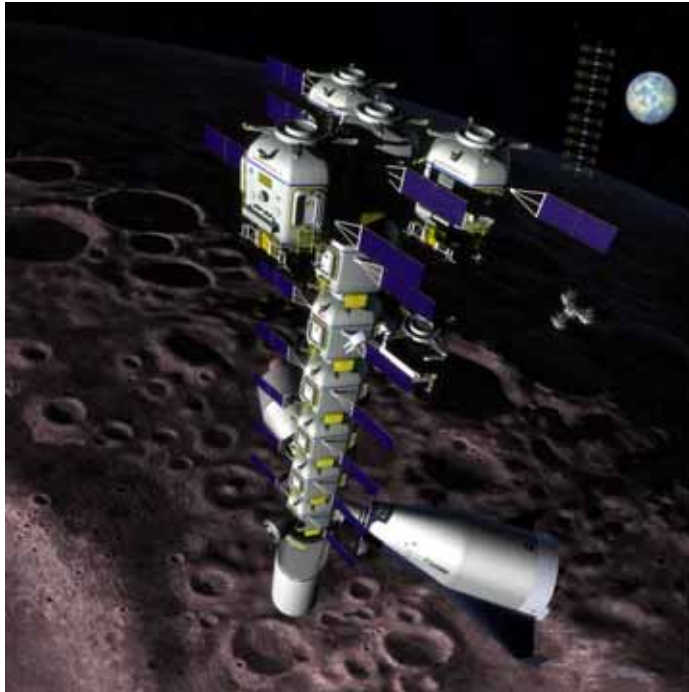
### **Risk Management**

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- **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 Systems 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.



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

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***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**

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***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 Administration (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.
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**Exploration Systems Research and Technology Theme Commitment in Support of the NASA Mission :**

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**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 |
|--|--------------|--------------|--------------|--------------|----------|
| <b>Exploration Systems Research and Technology</b> | <b>676.6</b> | <b>722.8</b> | <b>196.4</b> | <b>919.2</b> |          |
| 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)

| <u>Advanced Space Technology</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|----------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

**Theme:** Exploration Systems Research and Technology

**Program:** Advanced Space Technology

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### 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 energy 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.

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### Program Management

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

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### 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    |
| <b>Advanced Studies, Concepts, &amp; Tools</b>            |                         |    |    |    |    |    |    | Development of advanced systems concepts and systems analysis tools; advanced studies to identify and prioritize technology needs.   | Tech        | Oct-04 | Dec-20 |
|   |                         |    |    |    |    |    |    |  | Form        | Oct-03 | Sep-04 |
|   |                         |    |    |    |    |    |    |  | Dev         |        |        |
|   |                         |    |    |    |    |    |    |  | Ops         |        |        |
|   |                         |    |    |    |    |    |    |  | Res         |        |        |
| <b>Advanced Materials &amp; Structural Concepts</b>       |                         |    |    |    |    |    |    | Development of high-performance materials; advanced mechanisms; space environments and effects models; structural concepts for deployment and modular assembly.                                | Tech        | Oct-04 | Dec-20 |
|   |                         |    |    |    |    |    |    |  | Form        | Oct-03 | Sep-04 |
|   |                         |    |    |    |    |    |    |  | Dev         |        |        |
|   |                         |    |    |    |    |    |    |  | Ops         |        |        |
|   |                         |    |    |    |    |    |    |  | Res         |        |        |
| <b>Computing, Communications, Electronics and Imaging</b> |                         |    |    |    |    |    |    | Development of in-space computing; space communications and networking; electronics for extreme environments; sensing and imaging for exploration systems.                                     | Tech        | Oct-04 | Dec-20 |
|   |                         |    |    |    |    |    |    |  | Form        | Oct-03 | Sep-04 |
|   |                         |    |    |    |    |    |    |  | Dev         |        |        |
|   |                         |    |    |    |    |    |    |  | Ops         |        |        |
|   |                         |    |    |    |    |    |    |  | Res         |        |        |
| <b>Power, Propulsion, &amp; Chemical Systems</b>          |                         |    |    |    |    |    |    | Development of energy conversion, energy storage, power management and distribution; chemical and electrical propulsion; thermal management; chemical systems for processing in-situ resources | Tech        | Oct-04 | Dec-20 |
|   |                         |    |    |    |    |    |    |  | Form        | Oct-03 | Sep-04 |
|   |                         |    |    |    |    |    |    |  | Dev         |        |        |
|   |                         |    |    |    |    |    |    |  | Ops         |        |        |
|   |                         |    |    |    |    |    |    |  | Res         |        |        |
| <b>Software, Intelligent Systems, and Modeling</b>        |                         |    |    |    |    |    |    | Development of reliable software; intelligent systems for robotics, space operations, and systems health management; human-autonomy interaction; simulation and modeling approaches.           | Tech        | Oct-04 | Dec-20 |
|   |                         |    |    |    |    |    |    |  | Form        | Oct-03 | Sep-04 |
|   |                         |    |    |    |    |    |    |  | 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**

- 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.

**Theme:** Exploration Systems Research and Technology

**Program:** Advanced Space Technology

### **Risk Management**

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- **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 activities 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

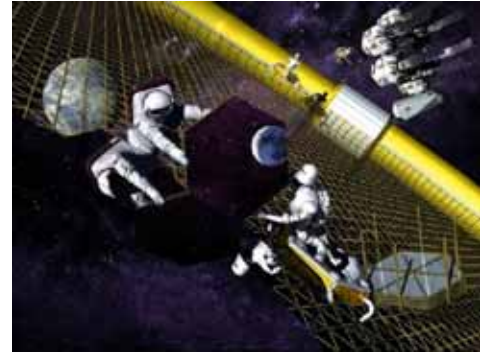
**Program:** Technology Maturation

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

| <u>Technology Maturation</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.



**Theme:** Exploration Systems Research and Technology

**Program:** Technology Maturation

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### 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.

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### 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.

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### Program Management

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

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### 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 electromagnetic 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              |
| <b>Advanced Space Operations</b>  |                         |    |    |    |    |    |    | Technology maturation for space assembly, maintenance, and servicing systems; intelligent onboard operations systems; ground operations systems.                                       | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Dec-10<br>Sep-04 |
| <b>Advanced Space Platforms and Systems</b>   |                         |    |    |    |    |    |    | Technology maturation for integrated systems health management; intelligent modular systems; habitation systems; communications networks.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Dec-20<br>Sep-04 |
| <b>High Energy Space Systems</b>  |                         |    |    |    |    |    |    | Technology maturation for solar power generation systems; cryogenic propellant refueling systems; electric propulsion systems; in-space cryogenic rocket engines; aero-assist systems. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Dec-20<br>Sep-04 |
| <b>Lunar and Planetary Surface Operations</b>   |                         |    |    |    |    |    |    | Technology maturation for surface mobility systems; in-situ resource utilization systems; surface manufacturing and construction systems; surface environmental management systems.    | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Apr-20<br>Sep-04 |
| <b>In-Space Technology Experiments Program</b>  |                         |    |    |    |    |    |    | Definition, development, and execution of flight experiments to validate new technologies for exploration missions.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Dec-20<br>Sep-04 |
| <p> </p> <ul style="list-style-type: none"> <li><span style="color: blue;">■</span> Tech &amp; Adv Concepts (Tech)</li> <li><span style="color: brown;">■</span> Formulation (Form)</li> <li><span style="color: yellow;">■</span> Development (Dev)</li> <li><span style="color: green;">■</span> Operations (Ops)</li> <li><span style="color: purple;">■</span> Research (Res)</li> <li><span style="color: black;">■</span> Represents a period of no activity for the Project</li> </ul> |                         |    |    |    |    |    |    |  |                                   |                  |                  |

**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.

**Theme:** Exploration Systems Research and Technology

**Program:** Technology Maturation

### **Risk Management**

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- **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 activities 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)

| <u>Innovative Partnerships</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 activities: Technology Transfer; Space Product Development; University Research and Engineering Institutes; Small Business Innovative Research projects; and Small Business Technology Transfer projects.

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.

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>.



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.

**Theme:** Exploration Systems Research and Technology

**Program:** Innovative Partnerships

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### **Plans For FY 2006**

Significant attention will be focused on reviewing and integrating the separate activities of the Innovative Partnerships program 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.

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### **Program Management**

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

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### **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 Research 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           |
| <b>Small Business Innovative Research</b>   | [Gantt chart: Tech & Adv Concepts (Tech) from 04 to 10] |    |    |    |    |    |    | Small Business Innovation Research fosters innovative technology development, increases small business participation in federal projects, and enhances private sector commercialization. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Dec-20 |
| <b>Small Business Technology Transfer Research</b>  | [Gantt chart: Tech & Adv Concepts (Tech) from 04 to 10] |    |    |    |    |    |    | Small Business Technology Transfer Research leverages the innovation of U.S. research institutions in conjunction with small business.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Dec-20 |
| <b>Technology Transfer</b>  | [Gantt chart: Tech & Adv Concepts (Tech) from 04 to 10] |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Dec-20 |
| <b>Space Product Development</b>  | [Gantt chart: Tech & Adv Concepts (Tech) from 04 to 10] |    |    |    |    |    |    | Space Product Development sponsors partnerships involving consortia of government, industry, and academia to conduct dual use research.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Dec-20 |
| <b>University Research and Technology Institutes</b>  | [Gantt chart: Tech & Adv Concepts (Tech) from 04 to 07] |    |    |    |    |    |    | University Research and Technology Institutes are grants for basic research in nanotechnology. Agreements expire in 2007 as initially planned.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Sep-07 |
| <p> <span style="display:inline-block; width:10px; height:10px; background-color:blue; border:1px solid black;"></span> Tech &amp; Adv Concepts (Tech)<br/> <span style="display:inline-block; width:10px; height:10px; background-color:yellow; border:1px solid black;"></span> Formulation(Form)<br/> <span style="display:inline-block; width:10px; height:10px; background-color:green; border:1px solid black;"></span> Development (Dev)<br/> <span style="display:inline-block; width:10px; height:10px; background-color:purple; border:1px solid black;"></span> Operations (Ops)<br/> <span style="display:inline-block; width:10px; height:10px; background-color:grey; border:1px solid black;"></span> Research (Res)<br/> <span style="display:inline-block; width:10px; height:10px; background-color:black; border:1px solid black;"></span> Represents a period of no activity for the Project         </p> |   |    |    |    |    |    |    |  |                                   |               |

**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)

| <u>Centennial Challenges</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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](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**

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- 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**

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

### **Key Participants**

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- 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.

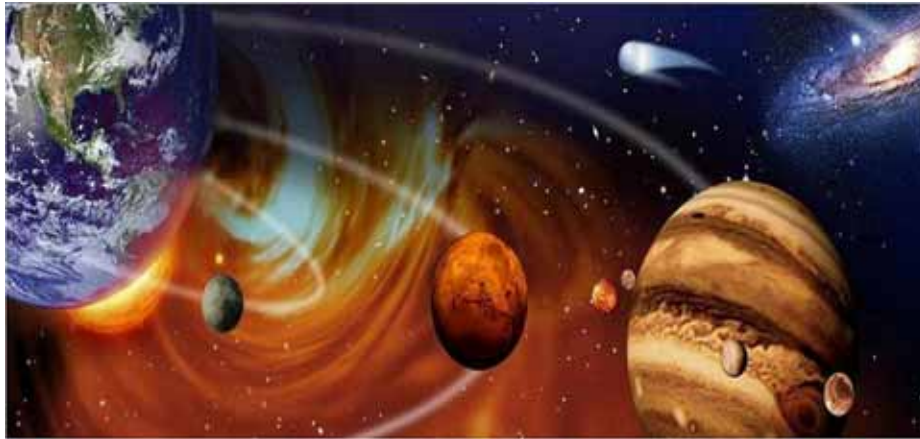
### **Risk Management**

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- **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.

***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.

**Performance**

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**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.

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**Prometheus Nuclear Systems and Technology Theme Commitment in Support of the NASA Mission :**

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**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.

**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 |
|--|--------|--------|--------|--------|----------|
| <b>Prometheus Nuclear Systems and Technology</b> |        | 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)

| <u>Advanced Systems and Technology</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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    |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Advanced Nuclear Electric Propulsion</b>  |  |    |    |    |    |    |    | Assess, research, and develop multiple advanced in-space propulsion technologies, including very high power nuclear electric systems to support future human exploration missions. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 | Sep-20 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Advanced Fission-Based Power Systems</b>  |  |    |    |    |    |    |    | Assess, research, and develop multiple high-power thermal-to-electrical system technologies needed for electric propulsion and advanced power applications.                        | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 | Sep-20 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Advanced Nuclear Propulsion Systems</b>   |  |    |    |    |    |    |    | Assess, research, and develop advanced nuclear propulsion technologies needed to support future human exploration missions and applications.                                       | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04 | Dec-10 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Long-Range Reactor Systems Technology</b>   |  |    |    |    |    |    |    | Assess, research, and develop systems and fuel technologies for high power levels needed for advanced human and robotic applications in future exploration missions.               | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 | Sep-10 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |                                   |        |        |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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

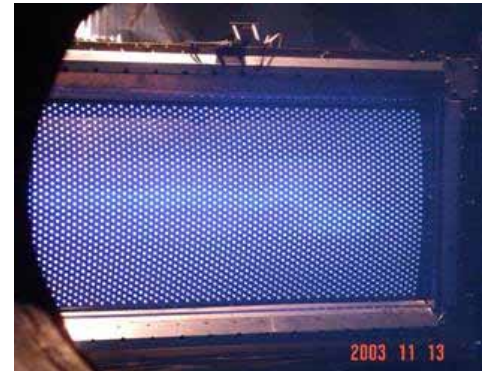
**Program:** Nuclear Flight Systems

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

| <u>Nuclear Flight Systems</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 accommodate 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 Prometheus 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  |             |        |        |

**Legend:**

- 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

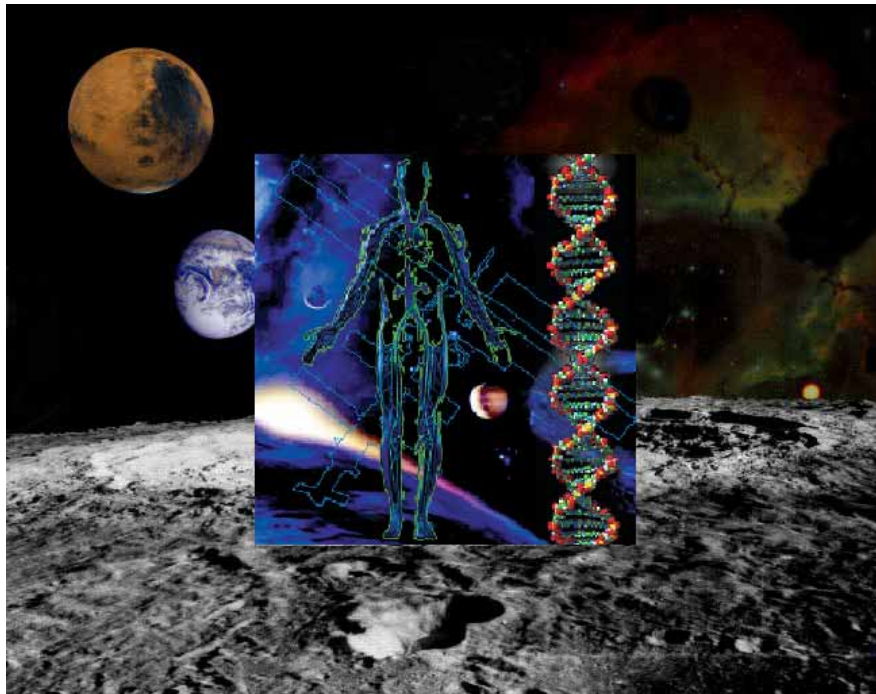
- Nuclear Flight Systems has partnered with the Department of Energy Office of Naval Reactors in the development of space nuclear reactor power plants.

### Risk Management

- RISK:** The key development and schedule risks for the Nuclear Flight Systems Program are the uncertainties 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.

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

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***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 vehicular 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**

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***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.
-

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

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**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.

**Theme: Human Systems Research and Technology**

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 |
|--|--------------|----------------|---------------|--------------|----------|
| <b>Human Systems Research and Technology</b> | <b>985.6</b> | <b>1,003.9</b> | <b>-197.4</b> | <b>806.5</b> |          |
| 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)

| <u>Life Support and Habitation</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

**Theme:** Human Systems Research and Technology

**Program:** Life Support and Habitation

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### **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.

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### **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.

| <b>Implementation Schedule:</b>               |                         |    |    |    |    |    |    |   |                                   |        |        |
|---|-------------------------|----|----|----|----|----|----|---|-----------------------------------|--------|--------|
| 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<br>Form<br>Dev<br>Ops<br>Res | Sep-04 | Dec-20 |
| Advanced EVA Systems                          |                         |    |    |    |    |    |    | Develops next-generation EVA technologies for in-space and surface exploration suits.   | Tech<br>Form<br>Dev<br>Ops<br>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<br>Form<br>Dev<br>Ops<br>Res | Sep-03 | Dec-20 |
| Applied Exploration Research                  |                         |    |    |    |    |    |    | Conducts advanced concepts exploration research that provides a foundation for new exploration technologies.  | Tech<br>Form<br>Dev<br>Ops<br>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<br>Form<br>Dev<br>Ops<br>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<br>Form<br>Dev<br>Ops<br>Res | Sep-03 | Dec-20 |
|   |                         |    |    |    |    |    |    |   |                                   |        |        |

**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 Broad Agency Announcement for HSR&T technologies specific to life support, habitation, and EVA technologies.

**Theme:** Human Systems Research and Technology

**Program:** Life Support and Habitation

### **Key Participants**

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- 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**

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- **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 CO<sub>2</sub> removal systems) to ensure the capability is 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)

| <u>Human Health and Performance</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

**Theme:** Human Systems Research and Technology

**Program:** Human Health and Performance

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### **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.

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### **Program Management**

This program is managed at NASA Headquarters and supported by technical and project management at the NASA Centers.

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### **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

| <b>Implementation Schedule:</b>   |  |    |    |    |    |    |    |   |                                   |               |                            |  |                   |  |                   |  |                  |  |                |  |  |
|---|--|----|----|----|----|----|----|---|-----------------------------------|---------------|----------------------------|--|-------------------|--|-------------------|--|------------------|--|----------------|--|--|
| 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<br>Form<br>Dev<br>Ops<br>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<br>Form<br>Dev<br>Ops<br>Res | Oct-04 Dec-10 |                            |  |                   |  |                   |  |                  |  |                |  |  |
| Autonomous Medical Care   | █  | █  | █  | █  | █  | █  | █  | Identify techniques to improve astronaut medical care and crew health optimization  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04 Dec-10 |                            |  |                   |  |                   |  |                  |  |                |  |  |
| Space Radiation   | █  | █  | █  | █  | █  | █  | █  | Evaluates the radiation risks to astronauts engaged in exploration missions.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04 Dec-10 |                            |  |                   |  |                   |  |                  |  |                |  |  |
| <table border="0"> <tr> <td style="width: 15px; height: 10px; background-color: #00B0F0;"></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td style="width: 15px; height: 10px; background-color: #8B4513;"></td> <td>Formulation(Form)</td> </tr> <tr> <td style="width: 15px; height: 10px; background-color: #FFD700;"></td> <td>Development (Dev)</td> </tr> <tr> <td style="width: 15px; height: 10px; background-color: #3CB371;"></td> <td>Operations (Ops)</td> </tr> <tr> <td style="width: 15px; height: 10px; background-color: #DDA0DD;"></td> <td>Research (Res)</td> </tr> <tr> <td style="width: 15px; height: 10px; background-color: #000000;"></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |                                   |               | Tech & Adv Concepts (Tech) |  | Formulation(Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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)

| <u>Human Systems Integration</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|----------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                 |               | 248.9         | 206.8         | 211.0         | 212.0         | 224.2         | 221.0         |

**Overview**

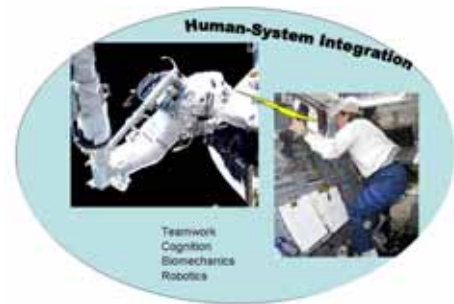
Human Systems Integration research and technology development is driven by Agency needs for crew health; design of human spacecraft, space suits, and habitats; efficient crew operations; medical operations; and technology development to enable safe and productive human space exploration.

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>



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.

**Theme:** Human Systems Research and Technology

**Program:** Human Systems Integration

### **Plans For FY 2006**

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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**

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- 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**

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This program is managed by NASA headquarters with significant participation from NASA Centers for technical and project support.



















### **Technical Description**

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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

| <b>Implementation Schedule:</b>   |  |    |    |    |    |    |    |   |             |      |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
|---|--|----|----|----|----|----|----|---|-------------|------|---|----------------------------|---|-------------------|---|-------------------|---|------------------|---|----------------|---|--|
| Project   | Schedule by Fiscal Year                            |    |    |    |    |    |    | Purpose   | Phase Dates |      |   |                            |   |                   |   |                   |   |                  |   |                |   |  |
|   | 04   | 05 | 06 | 07 | 08 | 09 | 10 |   |             | Beg  | End   |                            |   |                   |   |                   |   |                  |   |                |   |  |
| <b>Behavioral Health and Performance</b>  |  |    |    |    |    |    |    | 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  |                   |   |                  |   |                |   |  |
| <b>Space Human Factors Engineering</b>  |  |    |    |    |    |    |    | 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  |                   |   |                  |   |                |   |  |
| <b>Multi-User System and Support</b>  |  |    |    |    |    |    |    | Multi-User System and Support projects enable effective ISS operations and utilization.   | Tech        | Form | Dev   | Ops                        | Res   | Oct-03            | Feb-16  |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation(Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |             |      |  | Tech & Adv Concepts (Tech) |  | Formulation(Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|    | 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.



Theme

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**Aeronautics  
Technology**

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.

## AERONAUTICS RESEARCH

**Purpose**

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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

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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.)

***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**

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***Major Activities Planned for FY 2006:***

- Successfully complete the SATS integrated technology demonstration and assessment
- Develop strategic management tools for National 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.
-

**Aeronautics Technology Theme Commitment in Support of the NASA Mission :**

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**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 CO<sub>2</sub> or NO<sub>x</sub> 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)

**Theme:** Aeronautics Technology

*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**

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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 implementation 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 |
|--------------------------------|----------------|--------------|--------------|--------------|----------|
| <b>Aeronautics Technology</b>  | <b>1,056.8</b> | <b>906.2</b> | <b>-53.9</b> | <b>852.3</b> |          |
| 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        |          |

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

| <u>Aviation Safety and Security</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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](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 likelihood 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.

**Theme:** Aeronautics Technology  
**Program:** Aviation Safety and Security

### **Program Management**

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ARMD Program Management Council has program oversight responsibility and authority. The Projects are implemented by ARC, GRC, LaRC, & JPL.

### **Technical Description**

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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.



| <b>Implementation Schedule:</b>                          |                         |    |    |    |    |    |    |  |                                   |        |        |
|--|-------------------------|----|----|----|----|----|----|--|-----------------------------------|--------|--------|
| Project  | Schedule by Fiscal Year |    |    |    |    |    |    | Purpose  | Phase Dates                       |        |        |
|  | 04                      | 05 | 06 | 07 | 08 | 09 | 10 |  |                                   | Beg    | End    |
| <b>Vehicle Safety Technologies</b>                       |                         |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-97 | Sep-05 |
| <b>System Safety Technologies</b>                        |                         |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-97 | Sep-05 |
| <b>Weather Safety Technologies</b>                       |                         |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-97 | Sep-05 |
| <b>Aircraft &amp; system vulnerability mitigation</b>    |                         |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Apr-04 | Sep-09 |
| <b>System Vulnerability Detection</b>                    |                         |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Apr-04 | Sep-09 |
| <b>Secure Aircraft System for Information Flow</b>       |                         |    |    |    |    |    |    | Develop technologies & concepts for a protected airspace surveillance system; remote monitoring of acct. onboard systems & environment; and secure &harden acct. datalinks & onboard networks  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-09 |
| <b>Aircraft Systems Self Diagnosis and Self-Reliance</b> |                         |    |    |    |    |    |    | Dev & demo technologies that automatically detect & correct degraded conditions in flight critical systems & structural components; and provide control resiliency in unstable conditions      | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-10 |
| <b>Integrated Flight Deck Info Systems</b>               |                         |    |    |    |    |    |    | Advanced technology designs that promote optimal flight -crew performance, workload allocation, and situation awareness through the application of intuitive human-centered design principles  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-10 |
| <b>Threat and Human Error Management</b>                 |                         |    |    |    |    |    |    | Develop, demonstrate, and transfer technologies that prevent unsafe flight situations due to breakdown between human and machine interface   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-10 |
| <b>High Temperature Hazard Mitigation</b>                |                         |    |    |    |    |    |    | Develop, demonstrate, and transfer technologies that detect hidden fires and provide real time hot section engine prognostics  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-10 |
| <b>Design Tools &amp; Operations for In-Flight Icing</b> |                         |    |    |    |    |    |    | Develop & transfer technologies for sensing, fusing, and disseminating icing weather information; predicting in-flight icing effects; and improving weather hazards training                   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-10 |
| <b>Integrated Safety Data for Strategic Response</b>     |                         |    |    |    |    |    |    | Demonstrate a common time-delimited working prototype of a network-based integration of information sources allowing assessment of National Aviation System safety risk.                       | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 | Sep-10 |
|  |                         |    |    |    |    |    |    |  |                                   |        |        |

**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 technologies that inform and protect users of the Air Transportation System. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-09 Sep-12 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |                                   |               |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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)

| <u>Airspace Systems</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD        | 232.3         | 152.2         | 200.3         | 180.5         | 174.6         | 177.9         | 175.7         |

**Overview**

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](http://www.aero-space.nasa.gov/programs/program_org/asp.htm)

The Airspace Systems program develops advanced air transportation technologies, concepts, and modeling for a more efficient and global-interactive National Airspace System.

**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**

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ARMD Program Management Council has program oversight responsibility and authority. The Projects are implemented by ARC, GRC, & LaRC.

### **Technical Description**

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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.

Theme: Aeronautics Technology

Program: Airspace Systems

| <b>Implementation Schedule:</b>                        |                         |    |    |    |    |    |    |   |                                   |                  |                  |
|--|-------------------------|----|----|----|----|----|----|---|-----------------------------------|------------------|------------------|
| Project  | Schedule by Fiscal Year |    |    |    |    |    |    | Purpose   | Phase Dates                       |                  |                  |
|  | 04                      | 05 | 06 | 07 | 08 | 09 | 10 |   |                                   | Beg              | End              |
| <b>Small Aircraft Transportation System (SATS)</b>     |                         |    |    |    |    |    |    | Develop and demonstrate vehicle technologies to enable increased utilization of local and regional airports.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-01           | Oct-05           |
| <b>Virtual Airspace Modeling and Simulation (VAMS)</b> |                         |    |    |    |    |    |    | Develop future NAS operational concepts; develop modeling and simulation capability/ environment to assess new operational concepts at the domain and system level.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03           | Oct-06           |
| <b>Efficient Aircraft Spacing (EAS)</b>                |                         |    |    |    |    |    |    | Develop wake vortex operation procedures/standards to increase safety and capacity in the terminal area; develop distributed air/ground traffic management concepts.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Oct-08<br>Sep-04 |
| <b>Efficient Flight Path Management (EFPM)</b>         |                         |    |    |    |    |    |    | Develop strategic planning tools for Air Traffic Service Providers and Airline Operations Centers, which reduce delays in the NAS while increasing system throughput. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Oct-08<br>Sep-04 |
| <b>Strategic Airspace Usage (SAU)</b>                  |                         |    |    |    |    |    |    | Develop long-term decision support tools and strategic planning tools to evolve the NAS toward the envisioned future NAS.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Oct-08<br>Sep-04 |
| <b>Space-based Technologies (SBT)</b>                  |                         |    |    |    |    |    |    | Develop advanced communications, navigation, and surveillance (CNS) technologies and architectures.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04<br>Oct-03 | Oct-08<br>Sep-04 |
| <b>Human Measures and Performance (HMP)</b>            |                         |    |    |    |    |    |    | Develop human performance measurements and design standards.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04           | Oct-08           |
| <b>Technology Integration</b>                          |                         |    |    |    |    |    |    | Integrate technologies across project, domain, and infrastructure boundaries and conduct system studies and system analyses.  | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04           | Oct-08           |
| <b>Transformation of the National Airspace System</b>  |                         |    |    |    |    |    |    | Develop technology required for the establishment of an agile air traffic system that accommodates future requirements and readily responds to shifts in demand.      | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-09           | Sep-15           |
|  |                         |    |    |    |    |    |    |   |                                   |                  |                  |

### 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

**Theme:** Aeronautics Technology

**Program:** Airspace Systems

### **Risk Management**

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- **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 descope 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)

| <u>Vehicle Systems</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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](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 separate 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.

| <b>Implementation Schedule:</b>   |                         |    |    |    |    |    |    |   |                                   |                                |
|---|-------------------------|----|----|----|----|----|----|---|-----------------------------------|--------------------------------|
| Project   | Schedule by Fiscal Year |    |    |    |    |    |    | Purpose   | Phase Dates                       |                                |
|   | 04                      | 05 | 06 | 07 | 08 | 09 | 10 |   | Beg                               | End                            |
| <b>Subsonic Noise Reduction</b>   |                         |    |    |    |    |    |    | Flight demonstrated, validated 10dB noise reduction relative to the current best in fleet for subsonic transport category aircraft.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-04 Sep-10                  |
| <b>Sonic Boom Reduction</b>   |                         |    |    |    |    |    |    | Demonstration in flight that a fully shaped supersonic aircraft will produce sonic boom levels substantially lower than conventional aircraft, enabling regulatory reconsideration. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 Sep-11<br>Oct-04 Sep-05 |
| <b>Zero Emissions Demonstration</b>   |                         |    |    |    |    |    |    | Flight demonstration of zero emissions aircraft using hydrogen fuel cells and eliminating aircraft emissions due to carbon dioxide and oxides of nitrogen.                          | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-05 Sep-11<br>Oct-04 Sep-05 |
| <b>High-Altitude Long-Endurance Remotely-Operated A/C</b>   |                         |    |    |    |    |    |    | 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<br>Form<br>Dev<br>Ops<br>Res | Oct-04 Sep-15                  |
| <p> <span style="color:blue">■</span> Tech &amp; Adv Concepts (Tech)<br/> <span style="color:orange">■</span> Formulation(Form)<br/> <span style="color:yellow">■</span> Development (Dev)<br/> <span style="color:green">■</span> Operations (Ops)<br/> <span style="color:purple">■</span> Research (Res)<br/> <span style="color:black">■</span> Represents a period of no activity for the Project         </p> |                         |    |    |    |    |    |    |   |                                   |                                |



**Theme:** Aeronautics Technology

**Program:** Vehicle Systems

### **Strategy For Major Planned Acquisitions**

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- 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**

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- 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**

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- 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

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**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**

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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>.

**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 Programs

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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.

# 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 Education 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 information see: <http://education.nasa.gov/home/index.html>

**Relevance:** *Why* NASA conducts Education Programs work

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***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 pathfinder 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**

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***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.
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**Education Programs Theme Commitment in Support of the NASA Mission :**

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**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 education 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 targets 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 |
|--|--------------|--------------|--------------|--------------|----------|
| <b>Education Programs</b>                  | <b>230.4</b> | <b>216.8</b> | <b>-49.9</b> | <b>166.9</b> |          |
| 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         |          |



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

| <u>Elementary and Secondary Education</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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/eledandsec/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.

**Theme:** Education Programs  
**Program:** Elementary and Secondary Education

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### **Program Management**

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

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### **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.

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### **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.

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### **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.

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### **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.



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."

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 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.

**Theme:** Education Programs

**Program:** Higher Education

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### 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.

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### Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

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### 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.

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### 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.

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### 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.

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### 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)

| <u>E-Education</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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/techproffice/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

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### 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.

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### Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

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### 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 agency'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.

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### 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.

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### Key Participants

- e-Education activities may involve astronauts, engineers, scientists, and mathematicians from public and private sectors addressing NASA's related disciplines and topics.

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### 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)

| <u>Informal Education</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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 (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.

Informal Education provides stimulating experiences for science, technology, engineering, and mathematics learning outside of formal classroom environments.

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

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### 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.

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### Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

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### 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.

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### Key Participants

- The Nation's science centers, museums, planetariums, libraries, community-based organizations, and other informal education entities.

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### 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)

| <u>Minority University Research and Education</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| 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.

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>



NASA's outreach to minority institutions contribute to the development of science, technology, engineering, and mathematics.

**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.

**Theme:** Education Programs

**Program:** Minority University Research and Education

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### 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.

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### Program Management

Program management is the responsibility of the Chief Education Officer and will be conducted in accordance with current NASA policies and procedures.

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### 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.

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### 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.

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### 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.

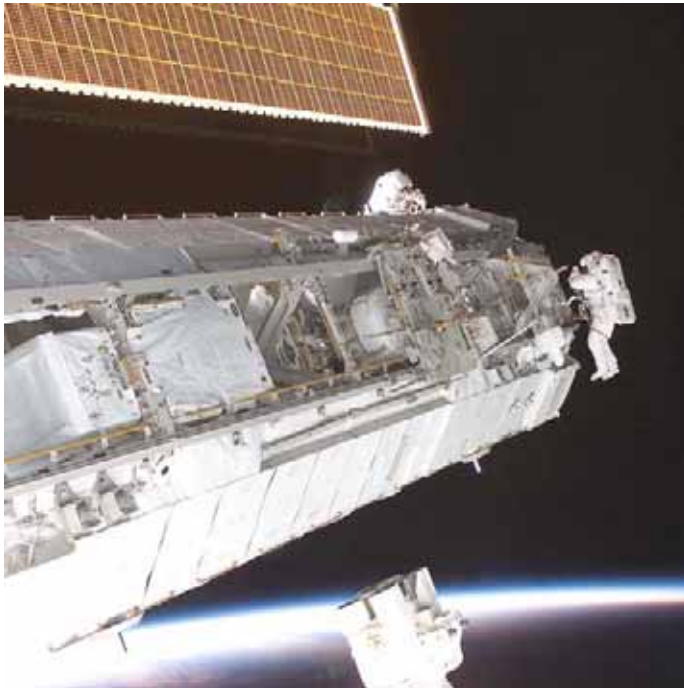
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### Risk Management

- **RISK:** The MUREP is a relatively low risk program. The primary risk is a loss of affiliation with the principal participants 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.

## Appropriation Summary: Exploration Capabilities

| Millions of Dollars               | FY 2004<br>9/28/04<br>Operating<br>Plan | FY 2005<br>12/23/05<br>Operating<br>Plan | FY 2006<br>Budget<br>Request |
|-----------------------------------|---|--|------------------------------|
| <b><u>SPACE OPERATIONS</u></b>    | <b><u>5,890.1</u></b>                   | <b><u>6,830.4</u></b>                    | <b><u>6,763.0</u></b>        |
| International Space Station       | 1,363.7                                 | 1,676.3                                  | 1,856.7                      |
| Space Shuttle                     | 4,060.9                                 | 4,669.0                                  | 4,530.6                      |
| Space and Flight Support          | 465.5                                   | 485.1                                    | 375.6                        |
| <b><u>TOTAL APPROPRIATION</u></b> | <b><u>5,890.1</u></b>                   | <b><u>6,830.4</u></b>                    | <b><u>6,763.0</u></b>        |



Astronauts Michael E. Lopez-Alegria and John B. Herrington work on the newly installed Port One truss on the International Space Station (ISS) during the STS-113 mission. The spacewalk lasted 6 hours, 10 minutes. The end effector of the Canadarm2 / Space Station Remote Manipulator System and Earth's horizon are visible in bottom of frame.

## Themes

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**International Space Station**

**Space Shuttle**

**Space and Flight Support**

# SPACE OPERATIONS

## Purpose

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The Space Operations Mission Directorate (SOMD) programs ensure that the Nation will have reliable, safe, and affordable access to space for NASA's human and robotic explorers and open new exploration and research opportunities through the extension of human presence in Space. The SOMD enables NASA to achieve its goals by providing transportation systems such as the Space Shuttle, operational research facilities in space such as the International Space Station (ISS); and space communications systems and supporting space infrastructure. The SOMD also provides the unique system--the human system--necessary to open the space frontier to the broadest extent possible.

## FY 2004 Accomplishments

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The SOMD entered FY 2004 with an evolving Shuttle Return to Flight (RTF) plan and the objective of resuming the assembly of the International Space Station (ISS) before the end of the following year. RTF efforts rapidly progressed from planning to hardware redesign, then to delivery of upgraded and new flight hardware during the year. By year's end, all indications were that the first Shuttle launch to the ISS could be safely achieved in May of 2005 and that ISS assembly might be resumed before the end of calendar year 2005. Meanwhile, SOMD continued close coordination with the ISS International Partners that enabled continuous on-orbit station operations in spite of the post-Columbia Shuttle stand-down. Using Russian-provided launch vehicles, the ISS supported a

## Mission Directorate: Space Operations

crew of two, successfully maintained critical onboard systems, continued to conduct research experiments, and maintained the capability to support continued ISS assembly after the first of two Shuttle RTF missions are completed. In the meantime, SOMD began planning for the phase-out of the Shuttle after the completion of ISS assembly, and began planning the transition to alternative launch services for long-term ISS logistic support and crew rotation.

The other Mission Directorates within NASA continue to maintain a high level of success for NASA missions using commercial launch services. All three NASA-managed launches of primary payloads in FY2004 were successful. Gravity Probe-B on April 20, 2004; Aura on July 15, 2004; and Messenger on August 3, 2004.

### Theme Distribution

| Budget Authority (\$ in millions) | FY 2004 | FY 2005 | FY 2006 |
|-----------------------------------|---------|---------|---------|
| International Space Station       | 1,363.7 | 1,676.3 | 1,856.7 |
| Space Shuttle                     | 4,060.9 | 4,669.0 | 4,530.6 |
| Space and Flight Support          | 465.5   | 485.1   | 375.6   |
| Total                             | 5,890.1 | 6,830.4 | 6,763.0 |

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.

### International Space Station

This Theme supports the construction and operations of a research facility in low Earth orbit as NASA's first step in achieving the Vision for Space Exploration. The ISS provides a unique, continuously operating capability to develop medical countermeasures for long-term human space travel: develop and test technologies and engineering solutions in support of exploration; and provide ongoing practical experience in living and working in space. It also supports a variety of pure and applied research for the U.S. and its International Partners. ISS assembly will be completed by the end of the decade. NASA is examining configurations for the Space Station that meet the needs of both the new space exploration vision and our international partners using as few Shuttle flights as possible. A key element of the ISS program is the crew and cargo services project, which will purchase services for cargo and crew transport using existing and emerging capabilities.

#### Overall Budget

The FY 2006 request is \$1,856.7 million; a \$180.4 million (or 11 percent) increase from the FY 2005 budget. Major features of this budget include:

- Funding is maintained throughout FY 2006 for continuous on-orbit operations and assembly after the Shuttle return to flight;
- Funding for Node 3 and the Environmental Control and Life Support System to accommodate research requirements beyond the baseline capability of U.S. and International Partner Core configuration;
- Funding for the acquisition of cargo and crew services to support the ISS.

### Space Shuttle

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The Space Shuttle is currently the only launch capability owned by the United States that enables human access to space, and the only vehicle that can support the assembly of the International Space Station (ISS). NASA will phase-out the Space Shuttle in 2010 when its role in ISS assembly is complete.

#### **Overall Budget**

The FY 2006 request is \$4,530.6 million; a \$138.4 million (or 3 percent) decrease from the FY 2005 budget. This budget will enable:

- Safe return to flight;
- Continuance of ISS assembly missions; and
- Planning for the phase-out of the Space Shuttle program in 2010, after nearly 30 years of duty.

### Space and Flight Support

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This theme encompasses Space Communications, Launch Services, Rocket Propulsion Testing, and Crew Health and Safety. Space Communications consists of (1) the Tracking and Data Relay Satellite System (TDRSS), which supports activities such as the Space Shuttle, ISS, Expendable Launch Vehicles, and research aircraft, and (2) the NASA Integrated Services Network, which provides telecommunications services at facilities, such as flight support networks, mission control centers and science facilities, and administrative communications networks for NASA Centers. The Launch Services program focuses on meeting the Agency's launch and payload processing requirements by assuring safe and cost-effective access to space via the Space Shuttle and expendable launch vehicles. Rocket Propulsion Testing supports a core of highly trained rocket test and engineering crews and test facilities. The Crew Health and Safety Program provide oversight and accountability for the total scope of health and safety of NASA's astronaut corps. Plum Brook Decommissioning will be shifted to Corporate G&A beginning in FY 2006.

#### **Overall Budget**

The FY 2006 request is \$375.6 million; a \$109.5 million (or 22 percent) decrease from the FY 2005 budget. The budget supports:

- Communications support of human and science missions;
- Launch services and support; and
- Rocket Propulsion Testing.

# International Space Station



The International Space Station is a complex of research laboratories in low Earth orbit for conducting unique scientific and technological investigations in the space environment.

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

| <u>International Space Station</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                   | 1,363.7       | 1,676.3       | 1,856.7       | 1,835.3       | 1,790.9       | 2,152.3       | 2,375.5       |
| Changes from FY 2005 Request       | -134.4        | -186.4        | 92.9          | 55.3          | 12.4          | 37.8          |               |

**Overview:** *What NASA Accomplishes through the International Space Station Theme*

The International Space Station (ISS) is a complex of research laboratories in low Earth orbit (LEO) in which American and International astronauts are conducting unique scientific and technological investigations in a space environment. The objective of the ISS is to support scientific research for human space exploration and other activities requiring the unique attributes of humans in space. Consistent with the Vision for Space Exploration, NASA is refocusing U.S. Space Station research on activities that will prepare human explorers to travel beyond LEO, such as the development of countermeasures against space radiation and the long-term effects of reduced gravity. Two crew members are onboard ISS and conducting research operations supported by resupply and crew rotation using Russian Progress and Soyuz vehicles. Increased science capability must wait until on-orbit assembly resumes after the Shuttle returns to flight.

The FY 2006 Budget request provides funding for ISS launch processing activities, vehicle on-orbit assembly with a crew of three, logistics resupply and crew exchange, continuation of research payload and experiment deliveries to orbit. It also includes funding for development of habitability modifications and completion of the regenerative environmental control and life support system needed to increase the crew capacity, consistent with human space exploration research requirements. NASA plans to complete assembly of the ISS by the end of the decade. NASA is examining ISS configurations that meet the needs of both the new space exploration vision and our international partners while using as few Shuttle flights as possible. A key element in the future of the ISS program is the purchase of alternate cargo and crew transportation services to supplement the Shuttle when it is in service, and to replace it when it retires.

**Relevance:** *Why* NASA conducts International Space Station work

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

The ISS serves as a platform for research activities that will prepare human explorers to travel beyond LEO. Research aboard the ISS is critical to: understanding the effects of space environments on the human body; developing techniques for mitigating these hazards; minimizing the logistical burden of supporting humans far from Earth; addressing remote medical emergencies; and demonstrating enabling technologies for human exploration. The ISS will vastly expand the human experience in living and working in space. The ISS represents an unprecedented level of international cooperation. The ISS Partnership agencies include NASA, the Russian Federal Space Agency (Roskosmos), the Canadian Space Agency (CSA), the European Space Agency (ESA), and the Japanese Aerospace Exploration Agency (JAXA). Additionally, there are several bilateral agreements between NASA and other nations such as Italy and Brazil, resulting in a total of 16 participating nations. International participation in the program has significantly enhanced the capabilities of the ISS.

***Relevance to the NASA mission:***

The Vision for Space Exploration outlines three tasks required for ISS: 1) Complete assembly by the end of the decade; 2) Focus U.S. research and use of the ISS on supporting space exploration goals; and 3) Conduct ISS activities in a manner consistent with international obligations.

***Relevance to education and public benefits:***

The ISS is the world's only space station and is central to NASA Vision and Mission. The ISS is a unique teaching tool, opening a new frontier for human learning and experience, allowing the Agency and its partners to pursue a series of related goals. The ISS enables the conduct of research to enable human and robotic exploration and development of space. No other facility can provide prolonged human research interaction in micro-gravity.

**Performance**

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***Major Activities Planned for FY 2006:***

- Resume assembly of ISS.
- Maintain on-orbit operations.
- Reestablish on-orbit crew of three as early as Shuttle flight ULF1.1.
- Select commercial transportation service provider(s).

***Major Recent Accomplishments:***

- Sustained two ISS crews during Shuttle stand down.
  - Expanded capabilities for inflight maintenance.
  - Demonstrated techniques for micromanaging consumables.
  - Completed four successful EVA's.
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**International Space Station Theme Commitment in Support of the NASA Mission :**

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**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.**

*8.1 By 2010 complete assembly of the ISS, including U.S. components that support U.S. space exploration goals and those provided by foreign partners.*

6ISS1 Reach agreement among the International Partners on the final ISS configuration.

*8.2 Annually provide 90 percent of the optimal on-orbit resources available to support research, including power, data, crew time, logistics, and accommodations.*

6ISS3 Provide 80 percent of FY 2006 planned on-orbit resources and accommodations to support research, including power, data, crew time, logistics and accommodations.

6ISS4 For FY 2006 ensure 90 percent functional availability for all ISS subsystems that support on-orbit research operations.

**17. Pursue commercial opportunities for providing transportation and other services supporting International Space Station and exploration missions beyond Earth orbit. Separate to the maximum extent practical crew from cargo.**

*17.1 By 2010, provide 80 percent of optimal ISS up-mass, down-mass, and crew availability using non-Shuttle crew and cargo services.*

6ISS2 Down select transportation service providers from FY 2005 ISS Cargo Acquisition RFP.

**Efficiency Measures**

6ISS5 Complete all development projects within 110% of the cost and schedule baseline.

6ISS6 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

**Program Management**

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The ISS Theme Director is General Michael C. Kostelnik, Deputy Associate Administrator for ISS and SSP, Space Operations Mission Directorate.

**Quality**

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**Independent Reviews:**

- Assessment of cost, schedule, and technical risks for crew enhancement option.

**Program Assessment Rating Tool (PART):**

The International Space Station received a FY 2006 OMB PART rating of: Moderately Effective.

This year's PART found that the program has taken a number of steps to address deficiencies identified last year: 1) The program had improved management and clarity of purpose, the Administration allowed the program to continue construction of the Space Station beyond the U.S. core complete stage; 2) The program has developed annual efficiency measures and improve outcome-oriented long-term performance measure. The program has developed improved new measures that can be used to drive future performance improvements; and, 3) The program has effectively managed its budget reserves, and recommended continued good reserve management to forestall future cost increases. NASA has continued to manage reserves effectively, but Congressional cuts and increases in Space Shuttle return-to-flight costs have eroded the reserves.

**Theme: International Space Station**

**Budget Detail**

(Dollars in Millions)

| Budget Authority (\$ millions)     | FY2004         | FY2005         | Change       | FY2006         | Comments |
|------------------------------------|----------------|----------------|--------------|----------------|----------|
| <b>International Space Station</b> | <b>1,363.7</b> | <b>1,676.3</b> | <b>180.4</b> | <b>1,856.7</b> |          |
| International Space Station        | 1,363.7        | 1,676.3        | 180.4        | 1,856.7        |          |

**COMPLIANCE WITH COST LIMITATIONS**

NASA's evaluation of this budget projects that the International Space Station may exceed the \$25 billion cost limitation imposed in the NASA Authorization Act of 2000 (P.L. 106-391). Due largely to an increase of \$40M for Columbia related impacts, ISS development is now projected to exceed 5% in FY 2005 and consequently all FY 2005 ISS costs (\$2.06B) will be added to the cumulative total as required by the Act. Costs subject to the cost limitation through FY 2005 are \$25.8B.

Prior to the Columbia accident, NASA projected that development, as defined by the Act, would be substantially completed by the first quarter of FY 2005. Since the accident, the ISS program operations budget has been reduced significantly by appropriations action and internal budget reallocations to support Shuttle return to flight. In addition, the time to complete ISS assembly has been extended by the grounding of the Shuttle fleet, and the ISS research budget has also been reduced. The combined affect of the budget reductions and the delay in completing assembly may result in the Space Station program technically exceeding the development cost limitation of \$25B in FY 2005 even though program development is essentially complete and program performance has improved steadily over the past three years. Strict compliance with the Act would preclude NASA from implementing safety related improvements to the ISS and upgrades in research capabilities needed to enable the Vision for Space Exploration.

Space Shuttle flights supporting ISS are within the \$17.7 billion cost limitation imposed by the act. This is based on the assumption that the point at which the ISS will be substantially complete as defined by the Act will be reached will occur in FY 2007, after which development spending will fall below 5% of the total annual budget.

Of the \$23.7 billion appropriated for the International Space Station and related activities from FY 1994 through FY 2004, approximately \$23.5 billion has been obligated as of September 30, 2004. Remaining FY 2004 funds will be obligated in the course of FY 2005 performance.

A separate report required by the Act will be prepared and submitted.

**Theme:** International Space Station  
**Program:** International Space Station Program

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

| <u>International Space Station Program</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                           | 1,363.7       | 1,676.3       | 1,856.7       | 1,835.3       | 1,790.9       | 2,152.3       | 2,375.5       |

**Overview**

The International Space Station (ISS) is a complex of research laboratories in low Earth orbit (LEO) in which American and international astronauts are conducting unique scientific and technological investigations in a space environment. The objective of the ISS is to support scientific research for human space exploration and other activities requiring the unique attributes of humans in space. Consistent with the Vision for Space Exploration, NASA is refocusing U.S. ISS research on activities that will prepare human explorers to travel beyond LEO, such as the development of countermeasures against space radiation and the long-term effects of reduced gravity.



The FY 2006 Budget request provides funding for the ISS launch processing activities, the resumption of vehicle on-orbit assembly with a crew of three, logistics resupply and crew exchange using the Space Shuttle, continuation of research payload and experiment deliveries to orbit. It also includes funding for full-scale development of habitability modifications and completion of the regenerative environmental control and life support system needed to increase the crew capacity, consistent with human space exploration research requirements.

The International Space Station in low Earth orbit.

NASA plans to complete assembly of the ISS by the end of the decade. NASA is examining ISS configurations that meet the needs of both the new space exploration vision and our international partners while using as few Shuttle flights as possible. A key element in the future of the ISS program is the purchase of alternate cargo and crew transportation services to supplement the Shuttle when it is in service, and to replace it when it retires.

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### **Plans For FY 2006**

During FY 2006, ISS will resume assembly, adding truss structure and Node 2 to accommodate attachment in international partner elements in subsequent years. As many as five assembly flights could take place during the fiscal year, but the exact assembly missions to be conducted will not be known until NASA completes its reassessment of the ISS final configuration. Crew size could be expanded once again to three international crew members and with Shuttle support expeditions could increase to three during the year. Included in the budget baseline for the first time is the funding to expand crew size beyond three. ISS will continue to provide safe and reliable assembly, activation, integration and operation of the ISS on-orbit. Ongoing activities in Mission Operations will provide the training, mission control operations, engineering support, and operations planning for continued safe flight. Safe and effective operation of the ISS will be NASA's number one priority. The Advanced Environmental Control and Life Support System, Node 3, and Habitability Upgrades will provide the necessary capabilities to support a total up to seven crew members. The development of the EXPRESS Pallet will begin in FY 2006 and continue through FY 2009. The development of the Space Station Power Transfer System, begun in FY 2004, will be completed in FY 2006.

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### **Changes From FY 2005**

- Resumption of U.S. crew rotation and logistics flights as the Space Shuttle returns to flight status.
- Greater than three crew capability included in baseline program.
- ISS reserves have been significantly impacted through appropriations reductions, full cost impacts and Shuttle RTF contributions.

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### **Program Management**

JSC is responsible for management of ISS core development. The NASA and JSC management Councils have program oversight responsibility.

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### **Technical Description**

The primary objective of the ISS is to support scientific research and other activities requiring the unique attributes of humans in space and is a crucial step in the Vision for Space Exploration. In concert with the new exploration vision, NASA will refocus U.S. Space Station research on activities such as the development of countermeasures against space radiation and the long-term effects of reduced gravity that prepare human explorers to travel beyond low Earth orbit.

**Theme:** International Space Station  
**Program:** International Space Station Program

| <b>Implementation Schedule:</b>  |  |    |    |    |    |    |    |  |             |      |     |                            |     |                    |        |                   |  |                  |  |                |  |  |
|--|--|----|----|----|----|----|----|--|-------------|------|-----|----------------------------|-----|--------------------|--------|-------------------|--|------------------|--|----------------|--|--|
| Project  | Schedule by Fiscal Year                            |    |    |    |    |    |    | Purpose  | Phase Dates |      |     |                            |     |                    |        |                   |  |                  |  |                |  |  |
|  | 04   | 05 | 06 | 07 | 08 | 09 | 10 |  |             | Beg  | End |                            |     |                    |        |                   |  |                  |  |                |  |  |
| ISS - Dates are subject to change  |  |    |    |    |    |    |    | Assembly Flight 12A - P3/P4 Truss Segment assembly | Tech        | Form | Dev | Ops                        | Res | Dec-05             | Feb-16 |                   |  |                  |  |                |  |  |
| ISS - Dates are subject to change  |  |    |    |    |    |    |    | Assembly Flight 12A.1 - P5 Truss segment assembly  | Tech        | Form | Dev | Ops                        | Res | Feb-06             | Feb-16 |                   |  |                  |  |                |  |  |
| ISS - Dates are subject to change  |  |    |    |    |    |    |    | Assembly Flight 13A - S3/S4 Truss Segment assembly | Tech        | Form | Dev | Ops                        | Res | Apr-06             | Feb-16 |                   |  |                  |  |                |  |  |
| ISS - Dates are subject to change  |  |    |    |    |    |    |    | Assembly Flight 13A.1 - S5 Truss Segment assembly  | Tech        | Form | Dev | Ops                        | Res | Jun-06             | Feb-16 |                   |  |                  |  |                |  |  |
| ISS - Dates are subject to change  |  |    |    |    |    |    |    | Assembly Flight 15A - S6 Truss Segment assembly    | Tech        | Form | Dev | Ops                        | Res | Sep-06             | Feb-16 |                   |  |                  |  |                |  |  |
| ISS - Dates are subject to change  |  |    |    |    |    |    |    | Assembly Flight 10A - Node 2 assembly              | Tech        | Form | Dev | Ops                        | Res | Dec-06             | Feb-16 |                   |  |                  |  |                |  |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |             |      |     | Tech & Adv Concepts (Tech) |     | Formulation (Form) |        | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|  | 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

- None

### Key Participants

- International Partners: There are a total of 16 participating nations working on the ISS. Russia, ESA, Japan, Canada, and Italy are providing elements for the International Space Station.
- Boeing: Prime contractor for International Space Station Development and Sustaining Engineering.
- Russia: in addition to ISS elements and crew members, under the partnership agreement Soyuz and Progress have provided critical crew rotation and resupply during the Shuttle down period.

## **Risk Management**

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- **RISK:** NASA does not currently have an agreement in place with Russia to provide rescue capability beyond FY 2005. Without crew rescue NASA will not be able to maintain crew presence on ISS. **MITIGATION:** NASA is continuing to work with the International Partners to develop a plan for crew rescue beyond FY 2005.
- **RISK:** ISS assembly is contingent on Shuttle return to flight. Delays will further delay ISS assembly and require NASA reliance on partner launch assets. Cost impacts and on-orbit supportability issues will continue to grow. **MITIGATION:** In order to mitigate cost impacts ISS has continued ground development and delivery of hardware to KSC. The ISS program continues to prepare and maintain readiness for Shuttle return to flight. Coordinated use of partner launch assets has also facilitated uninterrupted ISS operation.
- **RISK:** Resupply of consumables and spare parts. With Shuttle grounded the ISS program has a limited ability to deliver the consumables and spare parts which sustain the crew and hardware systems. If critical functions cannot be sustained the crew will be returned to Earth by Russia's Soyuz vehicle. Until onboard crew are restored, there will be a higher risk of loss of the ISS vehicle. **MITIGATION:** NASA and its International Partners are cooperating to sustain onboard crew and vehicle systems. Russia's Progress and Soyuz spacecraft are delivering the necessary resources while choices of cargo are in response to current and projected conditions. Existing onboard reserves are managed to accommodate system failures and last beyond the arrival of each planned resupply vehicle

# Space Shuttle



The program plays a vital role in exploring space and extending human presence across our solar system by providing critical support to the International Space Station.

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

| Space Shuttle                | FY2004  | FY2005  | FY2006  | FY2007  | FY2008  | FY2009  | FY2010  |
|------------------------------|---------|---------|---------|---------|---------|---------|---------|
| FY 2006 PRES BUD             | 4,060.9 | 4,669.0 | 4,530.6 | 4,172.4 | 3,865.7 | 2,815.1 | 2,419.2 |
| Changes from FY 2005 Request | 115.9   | 349.8   | 204.5   | -141.6  | -161.2  | -215.3  |         |

### Overview: *What NASA Accomplishes through the Space Shuttle Theme*

NASA is committed to supporting the first steps of the Vision for Space Exploration - completing the assembly of the International Space Station (ISS). The FY 2006 budget request assumes that the Space Shuttle will return to flight in late spring of 2005. NASA will retire the Space Shuttle once its role in Space Station assembly is complete. On January 14, 2004, the President said in announcing his Vision: "The Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station. In 2010, the Space Shuttle - after nearly 30 years of duty - will be retired from service."

International Space Station assembly will be completed by the end of the decade. NASA is examining configurations for the Space Station that meet the needs of both the new space exploration vision and our international partners using as few Shuttle flights as possible. This assessment is critical to allowing NASA to continue work on Space Station assembly safely and retire the Shuttle as planned to make way for the Crew Exploration Vehicle.

The Space Operations Mission Directorate (SOMD) has fundamentally changed the way that the agency goes about the business of human space flight through reexamining and revamping our engineering practices and culture. SOMD has taken actions to meet/exceed the Columbia Accident Investigation Board (CAIB) recommendations, as well as to "raise the bar" with a number of self generated related actions towards compliance and meeting the milestones necessary to support and ensure a safe Return to Flight.

**Relevance:** *Why* NASA conducts Space Shuttle work

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

In January 2004, President Bush announced the Vision for Space Exploration, which changed the long term focus of the Shuttle Program. The program's primary mission is to support space exploration by completing the assembly of the ISS as planned by the end of decade. The Space Shuttle will be retired in 2010. The Space Shuttle is currently the nation's only human-rated vehicle capable of supporting the ISS and activities in low earth orbit.

***Relevance to the NASA mission:***

The Space Shuttle supports NASA's mission by ensuring the provision of space access by increasing safety, reliability, and affordability through its remaining service life.

***Relevance to education and public benefits:***

The Space Shuttle provides long-term benefits to the public through support to the ISS program enabling researchers to undertake experiments in the unique environment of space. The Space Shuttle Program (SSP) is contributing to NASA's goal to excite students about science and mathematics and to help advance the Nation's education goals by supporting the Educator Astronaut Program.

**Performance**

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***Major Activities Planned for FY 2006:***

- Safely fly planned Space Shuttle manifest.
- Initiate early actions for an orderly phase-out of the program.
- Ensure the proper technical integration of all Shuttle elements.

***Major Recent Accomplishments:***

- Successful disposition of more than two dozen CAIB and CAIB-related recommendations, including NASA self-initiated "raising the bar" actions.
  - Delivered first set of fully modified flight hardware for assembly and checkout at launch site.
  - Resumed processing activities in preparation for return to flight in late spring of 2005.
  - Incorporated safety and management improvements after reassessing the Shuttle baseline program.
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**Space Shuttle Theme Commitment in Support of the NASA Mission :**

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**NASA Objectives**

*Multiyear Outcomes*

Annual Performance Goals supporting the Multiyear Outcomes

**6. Return the Space Shuttle to flight and focus its use on completion of the International Space Station, complete assembly of the ISS, and retire the Space Shuttle in 2010, following completion of its role in ISS assembly. Conduct ISS activities consistent with U.S. obligations to ISS partners.**

*6.1 Assure public, flight crew, and workforce safety for all Space Shuttle operations, and safely meet the manifest and flight rate commitment through completion of Space Station assembly.*

6SSP1 Achieve zero Type A (damage to property at least \$1M or death) or Type B (damage to property at least \$250K or permanent hospitalization of three or more persons) mishaps in 2006;



**Theme: Space Shuttle**

**Efficiency Measures**

6SSP2 Complete all development projects within 110% of the cost and schedule baseline.

6SSP3 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

**Program Management**

The Space Shuttle Theme Director is General Michael C. Kostelnik, Deputy Associate Administrator (ISS and SSP), Space Operations Mission Directorate.

**Quality**

**Independent Reviews:**

- Stafford-Covey Return to Flight Task Group - On-going review through FY 2004; will continue until first flight.
- Inspector General Review - June 2004, review of ET Thermal Protection System Debris Shedding Report.
- Inspector General Review - July 2004, Return to Flight Task Group Business Processes.
- Inspector General Review - September 2004, Solid Rocket Booster Bolt Catchers.
- Government Account Office (GAO) Report - November 2004, Space Shuttle Report - Cost for Hubble Science Mission and Implementation of Safety Recommendations.
- GAO Audit - NASA's Shuttle Workforce Change; Report due Spring 2005.
- Inspector General Review - Space Shuttle Imaging, On-going Review through FY 2004; will continue until CAIB recommendations fully implemented, last status April 2004.

**Program Assessment Rating Tool (PART):**

The Shuttle received a FY 2005 OMB PART rating of: Results Not Demonstrated

The assessment found that the Shuttle had improved its planning and management, but due to the tragic loss of Space Shuttle Columbia in February 2003, the program met almost none of its annual performance measures and made little progress towards achieving its long term goals.

Existing actions are: 1) Plan to retire the Shuttle when its role in assembling the ISS is complete; 2) Return the Shuttle safely to flight and continue using it to support the ISS; and , 3) Develop outcome-oriented short and long-term measures for the Space Shuttle Program.

**Budget Detail**

(Dollars in Millions)

| Budget Authority (\$ millions) | FY2004  | FY2005  | Change | FY2006  | Comments |
|--------------------------------|---------|---------|--------|---------|----------|
| Space Shuttle                  | 4,060.9 | 4,669.0 | -138.3 | 4,530.6 |          |
| Space Shuttle Program          | 4,060.9 | 4,669.0 | -138.3 | 4,530.6 |          |

**Theme:** Space Shuttle  
**Program:** Space Shuttle Program

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

| <u>Space Shuttle Program</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD             | 4,060.9       | 4,669.0       | 4,530.6       | 4,172.4       | 3,865.7       | 2,815.1       | 2,419.2       |

**Overview**

NASA is committed to achieving the first steps of the Vision for Space Exploration - completing the assembly of the International Space Station (ISS). The FY 2006 budget request assumes that the Space Shuttle will return to flight in late spring of 2005. The Space Operations Mission Directorate (SOMD) has fundamentally changed the way that the Agency goes about the business of human space flight through re-examining and re-vamping our engineering practices and culture following the Columbia tragedy. SOMD has taken actions to implement the Columbia Accident Investigation Board (CAIB) recommendations, as well as to "raise the bar" with a number of self-generated related actions initiated by NASA towards compliance and meeting the milestones necessary to support and ensure a safe return to flight.



Space Shuttle projects play a vital role in NASA's goal to explore space and extend human presence across the solar system by providing the critical support for launching the Shuttle to continue the assembly and operation of the International Space Station.

**Plans For FY 2006**

The program's primary mission is: to support space exploration by completing the assembly of the ISS as planned by the end of the decade; safely fly the planned Space Shuttle manifest; initiate early actions for an orderly transition of the program; and ensure the proper technical integration of all Shuttle elements.

**Changes From FY 2005**

- NASA continues to implement the CAIB recommendations for the Space Shuttle return to flight scheduled for the spring of 2005.
- Cancellation of the Cockpit Avionics Upgrade in December 2004.
- Completion of development for the Advanced Health Monitoring System Phase I Upgrade in FY 2005.



















**Program Management**

The Centers at JSC, KSC, MSFC, and SSC are responsible for SSP project management. The NASA and SOMD Program Management Councils have oversight.

**Technical Description**

The Space Shuttle comprises three major functions - Program Integration, Ground and Flight Operations and Flight Hardware. Program Integration assures the successful technical integration of all Shuttle elements and payloads into each mission. Ground and Flight Operations provides: final integration and checkout of all hardware elements for launch including support capability for launch countdown and landing; assures successful accomplishment of pre-flight planning; operations control activities; flight crew training and operations support; aircraft maintenance and operations; and life sciences mission operations. Flight Hardware assures the vehicle hardware and software are designed, developed, manufactured, and tested sufficiently to enable safe and reliable transportation.

**Implementation Schedule:**

| Project   | Schedule by Fiscal Year                            |    |    |    |    |    |    | Purpose   | Phase Dates                       |        |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
|---|--|----|----|----|----|----|----|---|-----------------------------------|--------|---|----------------------------|---|--------------------|---|-------------------|---|------------------|---|----------------|---|--|
|   | 04   | 05 | 06 | 07 | 08 | 09 | 10 |   | Beg                               | End    |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Flight and Ground Operations</b>   |  |    |    |    |    |    |    | Provides final integration/checkout of all elements for launch. Also includes a wide variety of planning, training, operations control, crew, life sciences, and aircraft support activities. | Tech<br>Form<br>Dev<br>Ops<br>Res | Dec-10 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Flight Hardware</b>  |  |    |    |    |    |    |    | Produces and maintains the various flight hardware and software elements.   | Tech<br>Form<br>Dev<br>Ops<br>Res | Dec-10 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <b>Program Integration</b>  |  |    |    |    |    |    |    | Ensures the proper technical integration of all Shuttle elements and payloads. Includes high-priority mission assurance projects for safety, supportability, and infrastructure.              | Tech<br>Form<br>Dev<br>Ops<br>Res | Dec-10 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <table> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |   |                                   |        |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|    | 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**

- Space Flight Operations - prime contractor for integration, ground and flight operations, Orbiter and SRB. Performer will be United Space Alliance.

**Risk Management**

- RISK:** Failure to complete External Tank modifications. Unlikely occurrence. Potential delay in Space Shuttle return to flight if modifications are not completed or additional modifications are required. **MITIGATION:** Continued to implement all the relevant CAIB recommendations and initiated an aggressive program to eliminate the technical problems for safe Shuttle flights to lessen the likelihood of a risk event.
- RISK:** Delay in implementation of Orbiter Boom Sensor Capability for first two flights. Unlikely occurrence. Potential delay in Space Shuttle return to flight if vehicle is not allowed to fly without this capability for first two flights. **MITIGATION:** Implementation of relevant CAIB recommendations to lessen the likelihood of a risk event occurring.
- RISK:** Failure to complete final External Tank Debris Assessment. Unlikely occurrence. Potential delay in Space Shuttle return to flight if additional risk is uncovered in assessment. **MITIGATION:** Implementation of all relevant CAIB recommendation to lessen the likelihood of a risk event occurring.

# Space and Flight Support



Space and Flight Support includes Space Communications, Launch Services, Rocket Propulsion Testing, and Crew Health and Safety program services.

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

| <u>Space and Flight Support</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                | 465.5         | 485.1         | 375.6         | 370.9         | 400.0         | 399.7         | 399.1         |
| Changes from FY 2005 Request    | 33.7          | -7.0          | -59.2         | -58.6         | -55.7         | -53.7         |               |

**Overview:** *What NASA Accomplishes through the Space and Flight Support Theme*

Space and Flight Support, managed by the Space Operations Mission Directorate, is comprised of several distinct Agency-level services. These services include Space Communications, Launch Services, Rocket Propulsion Testing (RPT), and Crew Health and Safety (CHS). These services are critical for conducting space exploration, aeronautical research, and biological and physical research. These services are provided to a wide range of customers, including NASA scientists and engineers, other Federal agencies, universities, foreign governments and industry interests.

Space and Flight Support transferred the Advanced Systems Program to Exploration Systems beginning in FY 2005, and the Environmental program budget (Plum Brook nuclear facility dismantling and environmental compliance and restoration) to the Corporate G&A account beginning in FY 2006.

## Theme: Space and Flight Support

**Relevance:** *Why* NASA conducts Space and Flight Support work

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

Space and Flight Support includes the enabling capabilities required to conduct space exploration and expand scientific knowledge of the Earth and our universe. Without these capabilities NASA could not perform many of its missions and the American public would not receive many benefits of the Nation's space program.

***Relevance to the NASA mission:***

Space and Flight Support enables NASA's ability to extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations. Each of these capabilities play a critical support role in the success of NASA's missions and goals.

***Relevance to education and public benefits:***

Benefits of Space and Flight Support include the relay of scientific data from space to Earth, the safe launching of Space Shuttles and expendable launch vehicles necessary for research, the assurance that rocket systems have been adequately tested, and the testing and implementation of various human health and illness prevention measures. A space program properly supported by this Theme will produce research data that can be used to generate new scientific knowledge through the study of the physical sciences, biological sciences, Earth sciences, planetary science, and more. These activities benefit both the general public and the education community.

### Performance

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***Major Activities Planned for FY 2006:***

- Support Space Shuttle return to flight.
- Launch six Expendable Launch Vehicles (ELV) of primary payloads.
- Implement the Mission Operation Voice Enhancement Upgrade Project and the Space Network Expansion Project.
- Participate in technology demonstration of miniature SAR/Communication integrated payload for Chandrayaan-1 mission.
- Evaluate concepts to support Exploration Systems Mission Directorate timelines.

***Major Recent Accomplishments:***

- Performed three successful NASA-managed ELV launches of primary payloads: Gravity Probe B on April 20, 2004, Aura on July 15, 2004 and Messenger on August 3, 2004.
  - Initiated Steering Committee for Communications and Navigation capability roadmap.
  - Successfully provided administrative and/or mission support through the NASA Space Network and the NASA Integrated Services Network.
  - Maximized efficiency and generated cost savings for NASA and other customers by minimizing duplication in propulsion test capabilities.
  - Initiated Space Communications Architecture Working Group.
-

**Space and Flight Support Theme Commitment in Support of the NASA Mission :**

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**NASA Objectives**

*Multiyear Outcomes*

Annual Performance Goals supporting the Multiyear Outcomes

**6. Return the Space Shuttle to flight and focus its use on completion of the International Space Station, complete assembly of the ISS, and retire the Space Shuttle in 2010, following completion of its role in ISS assembly. Conduct ISS activities consistent with U.S. obligations to ISS partners.**

*6.2 Provide safe, well-managed and 95 percent reliable space communications, rocket propulsion testing, and launch services to meet Agency requirements.*

6SFS1 Establish the Agency-wide baseline space communications architecture, including a framework for possible deep space and near Earth laser communications services.

6SFS2 Maintain NASA success rate at or above a running average of 95 percent for missions on the FY 2005 Expendable Launch Vehicle (ELV) manifest.

6SFS3 Achieve at least 95 percent of planned data delivery for the International Space Station, each Space Shuttle mission, and low-Earth orbiting missions for FY 2005.

6SFS4 Define and provide space transportation requirements for future human and robotic exploration and development of space to all NASA and other government agency programs pursuing improvements in space transportation.

**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.**

*8.3 Reduce Crew downtime due to health-related reasons during space flight missions.*

6SFS5 Achieve a 5 percent reduction in downtime.

*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.*

6SFS6 Certify medical fitness of all crew members before launch.

**Efficiency Measures**

6SFS7 Complete all development projects within 110% of the cost and schedule baseline.

6SFS8 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6SFS9 Increase the throughput of the Space Network and NASA Wide Area Network per unit cost on an annual basis.

**Program Management**

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The Theme Directors are Robert Spearing (Space Communications), Karen Poniatowski (Launch Services), Headquarters (CHS), and Stephen Brettel (RPT).

**Quality**

**Independent Reviews:**

- Under assessment

**Program Assessment Rating Tool (PART):**

Space and Flight Support received an FY 2006 PART rating of Adequate.

The assessment found that the programs were generally effective in providing services to NASA and other customers, but needed better plans to improve those services in the future.

Existing actions are: 1) Continue to fund the program at an essentially flat level, but strive to improve the program's results by increasing efficiency; 2) Develop, a plan to independently review all of the major program elements to support improvements and evaluate effectiveness and relevance; 3) Develop better measures that will help to drive program improvement; and 4) Remove ECR from the SFS portfolio and make it a part of NASAs corporate G&A costs.

**Budget Detail**

(Dollars in Millions)

| Budget Authority (\$ millions)  | FY2004       | FY2005       | Change        | FY2006       | Comments |
|---------------------------------|--------------|--------------|---------------|--------------|----------|
| <b>Space and Flight Support</b> | <b>465.5</b> | <b>485.1</b> | <b>-109.4</b> | <b>375.6</b> |          |
| Advanced Systems                | 14.3         |              |               |              |          |
| Plum Brook Decommissioning      | 84.2         | 75.4         | -75.4         |              |          |
| Space Communications            | 157.4        | 192.7        | -19.5         | 173.3        |          |
| Launch Services                 | 141.1        | 143.8        | -19.8         | 124.0        |          |
| Rocket Propulsion Testing       | 60.0         | 65.8         | 3.3           | 69.1         |          |
| Crew Health and Safety          | 8.5          | 7.4          | 1.9           | 9.3          |          |

**Theme:** Space and Flight Support

**Program:** Space Communications

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

| <u>Space Communications</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-----------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD            | 157.4         | 192.7         | 173.3         | 174.8         | 194.8         | 194.4         | 194.1         |

**Overview**

NASA's flight missions must be linked to the Earth to accomplish their mission objectives. Resulting in the economic advantages over separate systems, NASA uses a common infrastructure to provide these essential links. The responsibility of this infrastructure is vested with the Space Operations Mission Directorate's Space Communications Program. This multi-mission approach dramatically reduces operational costs.

When viewed as a unit, Space Communications activities are one part of an interdependent triad that is absolutely essential to this Nation's space programs. Space Communications functions, while often less visible, are no less vital than the payloads and the launch systems that carry them to their destinations. Mission success is possible only when all three elements meet their performance requirements.

One of the key challenges of the Program is predicting and understanding future mission communications needs and then determining how to meet those needs by incorporating new technology while stimulating and encouraging development of commercial sources. The budget for the Program is based upon flight missions' requirements and those technological development capabilities necessary to meet future mission needs. The Program is also developing a communication and navigation architecture that will support the Exploration and Science Programs through the 2030 time period.

The Program supports the Agency's goal to improve the provision of access to space for the Nation by making it increasingly safe, reliable, and affordable. For more information, please see <http://www.spacecomm.nasa.gov>.



Present complement of eight Satellites on-orbit.



**Theme:** Space and Flight Support

**Program:** Space Communications

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## Plans For FY 2006

Several major functions will continue into FY 2006:

1. Providing reliable, cost-effective operational support to NASA missions and non-NASA missions
2. Enhancing the Space Network (SN) space-to-ground link terminal
3. Conducting studies for a follow-on Tracking and Data Relay Satellites (TDRS) initiative in order to ensure continuity of TDRS services
4. Providing administrative, scientific, and mission control telecommunications services
5. Managing Data Standards with increased focus on transitioning to a more efficient international body
6. Managing NASA's access to Spectrum required to: conduct space and ground based radio transmission, operate navigation systems, and conduct mission sensor operations
7. Supporting the Spectrum environment studies to better understand frequency and device interferences
8. Conducting proof-of-concept demonstration of the Distress Alerting Satellite System involving placement of 406 Mhz distress beacon repeaters on the Global Positioning System

Critical systems are severely past the end of their lifetime. Replacement of systems that frequently fail and are costly to maintain is on-going. Mission Voice systems across the Agency will be replaced over the next several years in order to minimize risk to NASA missions.

Space communications and navigation architecture, responsive to the Vision for Space Exploration, is under development. Tasks will be identified to ensure cost-effective evolution of the architecture capabilities. Some technology initiatives will be restructured to better support the Exploration Program needs.

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## Changes From FY 2005

- There were no major programmatic changes from the FY 2005 budget submission.

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## Program Management

The SN, NISN, GN, DSN, and WATR networks are managed and funded by different Directorates. Managing control boards and working groups are established.

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## Technical Description

TDRS is the core of the SN providing in-flight communications with spacecraft operating in low-Earth orbit. SN provides uplink/downlink facilities at White Sands and Guam. NISN transports administrative, scientific, and mission control data among NASA facilities and its industrial/scientific partners. Both networks provide service to non-NASA missions on a reimbursable basis.

Other activities: initiating and managing communications and navigation technology initiatives to reduce cost; developing an architecture to support Exploration and Science Programs; managing access to communications frequencies in order to conduct space/ground based transmissions; and conducting proof-of-concept for a new space-based search and rescue system to improve distress alert and location capability.

**Theme:** Space and Flight Support

**Program:** Space Communications

| <b>Implementation Schedule:</b>  |  |    |    |    |    |    |    |  |                                   |               |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
|--|--|----|----|----|----|----|----|--|-----------------------------------|---------------|---|----------------------------|---|--------------------|---|-------------------|---|------------------|---|----------------|---|--|
| Project  | Schedule by Fiscal Year                            |    |    |    |    |    |    | Purpose  | Phase Dates                       |               |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
|  | 04   | 05 | 06 | 07 | 08 | 09 | 10 |  | Beg                               | End           |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| Space Communications   |  |    |    |    |    |    |    | Provide space communications support to all NASA missions and non NASA missions. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-03 Sep-10 |   |                            |   |                    |   |                   |   |                  |   |                |   |  |
| <table border="0"> <tr> <td></td> <td>Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td></td> <td>Formulation (Form)</td> </tr> <tr> <td></td> <td>Development (Dev)</td> </tr> <tr> <td></td> <td>Operations (Ops)</td> </tr> <tr> <td></td> <td>Research (Res)</td> </tr> <tr> <td></td> <td>Represents a period of no activity for the Project</td> </tr> </table> |  |    |    |    |    |    |    |  |                                   |               |  | Tech & Adv Concepts (Tech) |  | Formulation (Form) |  | Development (Dev) |  | Operations (Ops) |  | Research (Res) |  | Represents a period of no activity for the Project |
|   | 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**

- Mission Operations Voice Enhancement for telecommunications network. Full and Open Competition.

**Key Participants**

- Federal Government Agencies (Network support, Comm/Navigation Architecture, Standards and Spectrum Management, special studies).
- Corporations (Network and Systems implementation, Technology, Architecture, special studies).

**Risk Management**

- RISK: Reliability studies show an eventual need to procure additional TDRS satellites to meet legacy and projected new mission requirements on the SN.

Highly likely MITIGATION: Senior level discussions are on-going.

- RISK: Space Network (SN) services are provided to non-NASA missions on a reimbursable basis. This reimbursement, which is offset against the NASA budget request, is anticipated to continue at the current level through FY 2006. A decline in this reimbursement may require additional NASA appropriated funds for the SN.

Possible after 2006 MITIGATION: Discussions with reimbursable customers are on-going.

**Theme:** Space and Flight Support

**Program:** Launch Services

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

| <u>Launch Services</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD       | 141.1         | 143.8         | 124.0         | 116.1         | 122.8         | 123.0         | 122.6         |

**Overview**

Assuring reliable and cost effective access to space for civilian missions is critical to achieving the Vision for Space Exploration NASA has been asked to undertake for the Nation. NASA has assigned responsibility for understanding the full range of civil space launch needs to the Space Operations Mission Directorate Launch Services Program. This program, which works closely with other government agencies and the launch industry, seeks to ensure that the most safe, reliable, on time, cost-effective launch opportunities are available on a wide range of launch systems to achieve the national goals for leadership in understanding the earth and exploring the universe.

A key challenge of the Program is understanding the launch needs of the different civil government customers. These customers seek to: understand Earth processes, including use of weather satellites; explore the universe with planetary probes, Mars rovers, and orbiters; and, to enhance life on earth by understanding the universe in which we live using various scientific missions. The Program purchases fixed-price launch services from domestic suppliers and provides oversight to ensure that these valuable, one of a kind missions safely leave the earth to explore the world beyond.

The Program works with customers from universities, industry, government agencies and international partners from the earliest phase of a mission.

The funding provides the capability for NASA to maintain critical skills providing technical management of launch services on the full fleet of existing and new launch systems.



Messenger Launch on Delta II at Cape Canaveral on August 3, 2004.

**Theme:** Space and Flight Support

**Program:** Launch Services

**Plans For FY 2006**

FY 2006 funding supports a wide range of activity critical to fulfilling NASA's science and exploration agenda. The six NASA launches planned for FY 2006 are: Spacetech-5; Aeronomy of Ice in the Mesosphere (AIM); Solar Terrestrial Relations Observatory (STEREO); Dawn; New Horizons and Geostationary Operational Environmental Satellite O (GOES-O). Spacetech-5 and AIM will be flown on Pegasus XL vehicles, STEREO and Dawn on Delta IIs, New Horizons on an Atlas V and GOES-O on a Delta IV. See Science Mission Themes for mission details.

- Advanced planning and trade studies for some 20 scientific and exploration missions.
- Advanced planning to support International Space Station cargo services.
- Continued partnership with the Defense Advanced Research Projects Agency (DARPA) on the FALCON program seeking to enable new cost effective launch capability for small payloads.
- Advanced planning to support the evolving launch requirements for the Moon and Mars exploration.
- Complete certification of the new Delta IV and Atlas V launch systems planned for NASA use in FY 2006.

**Changes From FY 2005**

- There were no major programmatic changes from the FY 2005 budget submission.

**Program Management**

NASA consolidated responsibility for understanding and meeting Agency launch requirements in the Launch Services Program.

**Technical Description**

Applying lessons learned from the Columbia Accident Investigation, the Program has Agency responsibility for acquiring launch services from private sector suppliers and/or DoD and for gathering the necessary engineering talent focused on moving scientific inquiry safely from the ground to space. The technical team serves as the bridge between NASA customers and launch contractors to assure that standards for safety and mission success are consistently applied with one common objective: To provide the systems level engineering oversight that strives to offer every NASA mission an opportunity to leave the Earth on a journey of exploration. This team has achieved a high level of mission success for NASA missions and consistently outperforms its goal of 95 percent or better launch success.

| <b>Implementation Schedule:</b> |                         |    |    |    |    |    |    |  |             |      |               |
|---------------------------------|-------------------------|----|----|----|----|----|----|--|-------------|------|---------------|
| Project                         | Schedule by Fiscal Year |    |    |    |    |    |    | Purpose  | Phase Dates |      |               |
|                                 | 04                      | 05 | 06 | 07 | 08 | 09 | 10 |  | Beg         | End  |               |
| Launch Services                 |                         |    |    |    |    |    |    | Responsible for enabling access to space for all NASA missions and other select government missions as required. | Tech        | Form | Oct-03 Sep-10 |
|                                 |                         |    |    |    |    |    |    |  | Dev         |      |               |
|                                 |                         |    |    |    |    |    |    |  | Ops         |      |               |
|                                 |                         |    |    |    |    |    |    |  | Res         |      |               |
|                                 |                         |    |    |    |    |    |    |  |             |      |               |

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

**Theme:** Space and Flight Support

**Program:** Launch Services

### **Strategy For Major Planned Acquisitions**

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- The Expendable Launch Vehicle Integrated Support (ELVIS) contract base period expires 9/30/05. The Program Office will evaluate and recommend whether existing options will be exercised.
- The NASA Launch Services ELV contracts have a bi-annual on-ramp period available to the Launch Services every February and August for new emerging Launch Services providers to be considered.

### **Key Participants**

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- Domestic launch service providers offering vehicles in all sizes from a variety of launch locations.
- Reimbursable Federal agency customers (NOAA, MDA).
- Other Federal agencies engaged in space launch (DOD, USAF, NRO, DARPA) to collaborate and coordinate the use of limited launch infrastructure assets.

### **Risk Management**

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- **RISK:** The lack of growth in the commercial launch market has placed a great strain on domestic launch providers' ability to offer government users a full range of launch opportunities. **MITIGATION:** The Program utilizes the Flight Planning Board as the Forum to aggregate Agency requirements and enable a purchasing strategy that helps to sustain capability in different market niches. The Program coordinates with other government space launch users to understand market impacts on space launch and work together on creative mitigation approaches.
- **RISK:** Launch systems are designed and operated by humans and have a less than 100 percent reliability. NASA missions, often one of a kind payloads, warrant an assured access to space strategy that is constantly vigilant and strives for success. **MITIGATION:** Assure the Program has the resources and tools needed to continue to provide the Nation with highly skilled systems level engineering talent focused on leveraging partnerships with industry and other government agencies to achieve sustained mission success for the full range of civil missions seeking access to space.

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

| Rocket Propulsion Testing | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|---------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD          | 60.0   | 65.8   | 69.1   | 70.1   | 71.8   | 71.9   | 72.1   |

**Overview**

The Rocket Propulsion Test (RPT) Program manages NASA's rocket propulsion test assets, activities, and resources; advances test technologies; and reduces propulsion test costs through the safe and efficient utilization of rocket propulsion test facilities in support of NASA programs, commercial partners, and the Department of Defense (DoD). The Program ensures appropriate levels of capability and competency are maintained for items such as engine development and certification, flight support testing, anomaly resolution, upgrades, life cycle testing, and certification extensions.

The Program strategy is to: fund and maintain a core capability of skilled test and engineering crews and test stand facilities; consolidate and streamline NASA's rocket test infrastructure; establish and maintain world-class test facilities; modernize test facility equipment; provide non-project specific equipment and supplies; and develop effective facility/infrastructure maintenance strategies and performance. The performing Centers are located at: Stennis Space Center (SSC), Marshall Space Flight Center (MSFC), Johnson Space Center-White Sands Test Facility (JSC-WSTF), and Glenn Research Center-Plum Brook Station (GRC-PBS). These facilities have a replacement value of two billion dollars.

RPT supports several National Strategic Objectives including: returning the Space Shuttle to flight; developing a new Crew Exploration Vehicle for missions beyond low Earth orbit; and developing and demonstrating power generation and propulsion capabilities required to support exploration of Mars and other destinations. Further information can be found at: <https://rockettest.ssc.nasa.gov/>



The Rocket Propulsion Test Program is performed at four NASA Centers.

**Theme:** Space and Flight Support  
**Program:** Rocket Propulsion Testing

### Plans For FY 2006

Support for the current inventory of 32 test stands in various operational states ranging from active to mothballed will continue to be funded. Studies to identify "at-risk" support and test facilities will be completed and used to assist in funding decisions relative to supporting the Vision for Space Exploration. In addition, the RPT Program will continue to assist in the requirements definition for some low Earth orbit and in-space propulsion systems and related technologies. Investments in infrastructure for RPT performing Centers are planned. Specifically, refurbishments to the steam system at Glen Research Center - Plum Brook Station are planned. The Program Commitment Agreement was drafted in FY 2004 and submitted to Space Operations Mission Directorate for formal review and acceptance. The Program Management Plan was also drafted and coordinated with the performing RPT Centers in FY 2004. Efforts are underway to have both program documents approved and signed during FY 2005.

### Changes From FY 2005

- No significant changes.

### Program Management

The Program Office is located at SSC. The management of the program is accomplished through the RPT Management Board chaired by the Program Manager.

### Technical Description

RPT provides for non-programmatic support of test facilities at the performing Centers. This includes funding for test facility management, maintenance, sustaining engineering, operations, and facility modernization required to keep test-related facilities in a state of operational readiness. The RPT budget does not include resources to support the marginal costs of testing (e.g., direct labor, propellants, materials, program-unique facility modifications, etc.) since these activities are to be funded by programs as a direct cost when they occupy the RPT test stands. NASA, DoD, and commercial partners schedule time for the RPT-supported test stands. The scheduled time may include program-specific facility modifications in addition to the testing of the program-specific test article.

| <b>Implementation Schedule:</b>   |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |
|---|-------------------------|----|----|----|----|----|----|---|-----------------------------------|---------------|--|---|---|---|--|---|
| Project   | Schedule by Fiscal Year |    |    |    |    |    |    | Purpose   | Phase Dates                       |               |  |   |   |   |  |   |
|   | 04                      | 05 | 06 | 07 | 08 | 09 | 10 |   | Beg                               | End           |  |   |   |   |  |   |
| Rocket Propulsion Test Program  |                         |    |    |    |    |    |    | Provides development of space transportation propulsion systems by sustaining "world-class" core capabilities required by rocket engine development and testing programs. | Tech<br>Form<br>Dev<br>Ops<br>Res | Oct-96 Sep-10 |  |   |   |   |  |   |
| <table border="0"> <tr> <td><span style="display:inline-block; width:15px; height:10px; background-color:blue; border:1px solid black;"></span> Tech &amp; Adv Concepts (Tech)</td> </tr> <tr> <td><span style="display:inline-block; width:15px; height:10px; background-color:orange; border:1px solid black;"></span> Formulation(Form)</td> </tr> <tr> <td><span style="display:inline-block; width:15px; height:10px; background-color:yellow; border:1px solid black;"></span> Development (Dev)</td> </tr> <tr> <td><span style="display:inline-block; width:15px; height:10px; background-color:green; border:1px solid black;"></span> Operations (Ops)</td> </tr> <tr> <td><span style="display:inline-block; width:15px; height:10px; background-color:purple; border:1px solid black;"></span> Research (Res)</td> </tr> <tr> <td><span style="display:inline-block; width:15px; height:10px; background-color:black; border:1px solid black;"></span> Represents a period of no activity for the Project</td> </tr> </table> |                         |    |    |    |    |    |    |   |                                   |               | <span style="display:inline-block; width:15px; height:10px; background-color:blue; border:1px solid black;"></span> Tech & Adv Concepts (Tech) | <span style="display:inline-block; width:15px; height:10px; background-color:orange; border:1px solid black;"></span> Formulation(Form) | <span style="display:inline-block; width:15px; height:10px; background-color:yellow; border:1px solid black;"></span> Development (Dev) | <span style="display:inline-block; width:15px; height:10px; background-color:green; border:1px solid black;"></span> Operations (Ops) | <span style="display:inline-block; width:15px; height:10px; background-color:purple; border:1px solid black;"></span> Research (Res) | <span style="display:inline-block; width:15px; height:10px; background-color:black; border:1px solid black;"></span> Represents a period of no activity for the Project |
| <span style="display:inline-block; width:15px; height:10px; background-color:blue; border:1px solid black;"></span> Tech & Adv Concepts (Tech)  |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |
| <span style="display:inline-block; width:15px; height:10px; background-color:orange; border:1px solid black;"></span> Formulation(Form)   |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |
| <span style="display:inline-block; width:15px; height:10px; background-color:yellow; border:1px solid black;"></span> Development (Dev)   |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |
| <span style="display:inline-block; width:15px; height:10px; background-color:green; border:1px solid black;"></span> Operations (Ops)   |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |
| <span style="display:inline-block; width:15px; height:10px; background-color:purple; border:1px solid black;"></span> Research (Res)  |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |
| <span style="display:inline-block; width:15px; height:10px; background-color:black; border:1px solid black;"></span> Represents a period of no activity for the Project   |                         |    |    |    |    |    |    |   |                                   |               |  |   |   |   |  |   |

### Strategy For Major Planned Acquisitions

- A new Test Operations Contract, TOC, was in place effective 1 September 2004. The TOC allows critical test operations skills and efficiencies to be maintained and shared between affected Centers.

**Theme:** Space and Flight Support

**Program:** Rocket Propulsion Testing

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### **Key Participants**

- The primary contractors for Technical Services and Support are Jacobs-Sverdrup, Mississippi Space Services, Honeywell, and Plum Brook Operations Support Group.

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### **Risk Management**

- **RISK:** A formal Risk Management Plan is in development in FY 2005. **MITIGATION:** Plan is in development.



**Theme:** Space and Flight Support

**Program:** Crew Health and Safety

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

| <u>Crew Health and Safety</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|-------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD              | 8.5           | 7.4           | 9.3           | 9.8           | 10.6          | 10.4          | 10.3          |

**Overview**

The purpose of the Crew Health and Safety (CHS) Office is to raise awareness and accountability for the total scope of health and safety of NASA's astronaut corps. The CHS Office is responsible for providing a program of comprehensive health care necessary to enable a healthy and productive crew during all phases of spaceflight missions, and to prevent and mitigate long-term negative health consequences. The major functions of Crew Health and Safety are to provide headquarters leadership, advocacy and support for efforts to: design, implement, and manage a comprehensive health care program for spaceflight; provide mission support on operational health-related issues and tasks; conduct astronaut medical selection certification and health maintenance; and conduct technology development and clinical operational efforts required to support long-duration spaceflight missions.



(28 April 1998) --- Jay C. Buckey, Jr., and James A. Pawelczyk, payload specialists, conducting human autonomic experiments in the Neurolab of the Earth-orbiting Space Shuttle Columbia.

**Plans For FY 2006**

NASA will finalize the development of a standardized battery of clinical and physiological tests for all crewmembers, to use in health risk/operations impact analysis. Workshops are planned to refine evidence-based information with the intent of applying this information to operational medicine. Crew Health Surveillance special projects include a two-year study of the effect of space flight on pharmacologic agents determining whether or not space flight significantly alters the effectiveness of medications. Real-Time Mission Evaluation supports the definition/implementation of medical care system requirements for all missions in conjunction with medical operations efforts. This is a program that responds as needed to address problems that may arise with medical care systems. Ongoing maintenance of the Longitudinal Study of Astronaut Health which archives astronaut medical record information in database form and performs data analyses to support clinical care and long-term health assessments of the astronauts. Remote Medical Diagnostic and Informatics will design, implement and maintain a comprehensive data management infrastructure to support the objectives of the Space Medicine Program. The Health Maintenance System Inventory Tracking Tool and Mission Planning Tool will be implemented this year. NASA will continue adding all forms of clinical data to the Computerized Medical Information System, which is an electronic medical record used for real-time documentation of clinical care at the point of care. Develop and maintain environmental standards for all space exploration platforms. Design, develop, and implement a comprehensive health care system for space flight.

**Theme:** Space and Flight Support

**Program:** Crew Health and Safety

### Changes From FY 2005

- There were no major programmatic changes from the FY 2005 budget submission.

### Program Management

Crew Health and Safety is managed at Headquarters, with its core programs performed for SSP and ISS by the Life Sciences Directorate at JSC.

### Technical Description

Manage health care for entire Astronaut Corps, both in space and during ground-based training. Certify the medical health of astronauts before flight and provide them with care throughout their careers. Medically support the FY 2005 Shuttle return to flight activities including planning, training, and medical operations support.

| <b>Implementation Schedule:</b> |                         |    |    |    |    |    |   |             |        |        |
|---------------------------------|-------------------------|----|----|----|----|----|---|-------------|--------|--------|
| Project                         | Schedule by Fiscal Year |    |    |    |    |    | Purpose   | Phase Dates |        |        |
|                                 | 04                      | 05 | 06 | 07 | 08 | 09 |   | 10          | Beg    | End    |
| Crew Health and Safety(CHS)     |                         |    |    |    |    |    | Protects our astronauts from the hazards of space travel and identifies methods that allow astronauts to improve their performance. | Tech        |        |        |
|                                 |                         |    |    |    |    |    |   | Form        |        |        |
|                                 |                         |    |    |    |    |    |   | Dev         |        |        |
|                                 |                         |    |    |    |    |    |   | Ops         | Oct-03 | Sep-10 |
|                                 |                         |    |    |    |    |    |   | Res         |        |        |
|                                 |                         |    |    |    |    |    |   |             |        |        |

**Legend:**

- 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 major acquisition planned.

### Key Participants

- The International Partners are involved in many areas of operational medicine planning.

## Overview

The NASA Office of Inspector General (OIG) budget request for Fiscal Year 2006 is \$32.4 million. The request supports our mission to prevent and detect crime, fraud, waste, abuse, and mismanagement while promoting economy, effectiveness, and efficiency within the Agency. This request represents the OIG resources needed at NASA Headquarters and field offices to fulfill the OIG mission. Recognizing that the number of identified audits, investigations, inspections, assessments, and other activities significantly exceed the available resources; continuous adjustments of priorities will be necessary to ensure that a balanced coverage of NASA's programs and operations is maintained, critical and sensitive matters are promptly evaluated and investigated, and that all OIG customers receive timely, accurate, and complete responses.

The OIG, Office of Audits (OA) conducts independent, objective audits and reviews of NASA and NASA contractor programs and projects to improve NASA operations as well as a broad range of professional audit and advisory services. It also comments on NASA policies and is responsible for the oversight of audits performed under contract or by other Federal agencies. The OA helps NASA accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the economy, efficiency and effectiveness of NASA operations.

The OIG Office of Investigations (OI) identifies, investigates, and refers for prosecution cases of crime, waste, fraud, and abuse in NASA programs and operations. The OIG's Federal law enforcement officers investigate false claims, false statements, conspiracy, theft, mail fraud, and violations of Federal laws, such as the *Procurement Integrity Act* and the *Anti-Kickback Act*. Through its investigations, the OI also seeks to prevent and deter crime at NASA. The OI Computer Crimes unit has solved cases involving extortion of NASA and contractor personnel, loss of communications services, and the use of NASA-funded networks to further criminal enterprises including the compromise of advanced technologies and industrial espionage.

NASA's OIG FY 2006 request is broken out as follows:

- 82.7 percent of the proposed budget is dedicated to personnel and related costs, including salaries, benefits, monetary awards, worker's compensation, transportation subsidies and training, as well as the government's contributions for Social Security, Medicare, health and life insurance, retirement accounts, matching contributions to Thrift Savings Plan accounts, the required 25 percent law enforcement availability pay for criminal investigators, and permanent change of station costs.
- 4.0 percent of the proposed budget is dedicated to travel, including the cost of transportation, per diem at current rates, and related expenses. The OIG staff is located at 14 offices in or near NASA installations and contractor facilities.
- 13.3 percent of the proposed budget is dedicated to operations and equipment, including government vehicles, special equipment for criminal investigators, and information technology equipment unique to the OIG. The Agency's annual financial audit is included in this funding.

| Budget Authority (\$ in millions) | FY 2004     | FY 2005     | FY 2006     |
|-----------------------------------|-------------|-------------|-------------|
| Personnel and Related Costs       | 23.0        | 25.5        | 26.8        |
| Travel                            | 1.2         | 1.2         | 1.3         |
| Operations and Equipment          | 2.9         | 4.6         | 4.3         |
| <b>Total</b>                      | <b>27.1</b> | <b>31.3</b> | <b>32.4</b> |

National Aeronautics and Space Administration Proposed Appropriation Language

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SCIENCE, AERONAUTICS AND EXPLORATION  
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses, not otherwise provided for, in the conduct and support of science, aeronautics and exploration research and development activities, including research, development, operations, support and services; maintenance; construction of facilities including repair, rehabilitation, revitalization, and modification of facilities, construction of new facilities and additions to existing facilities, facility planning and design, and restoration, and acquisition or condemnation of real property, as authorized by law; environmental compliance and restoration; space flight, spacecraft control and communications activities including operations, production, and services; program management; personnel and related costs, including uniforms or allowances therefore, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; not to exceed \$35,000 for official reception and representation expenses; and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, \$[7,742,550,000] 9,661,000,000, to remain available until September 30, [2006] 2007, of which amounts as determined by the Administrator for salaries and benefits; training, travel and awards; facility and related costs; information technology services; science, engineering, fabricating and testing services; and other administrative services may be transferred to "Exploration Capabilities" in accordance with section 312(b) of the National Aeronautics and Space Act of 1958, as amended by Public Law 106-377. (*Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2005.*)

EXPLORATION CAPABILITIES  
(INCLUDING TRANSFER OF FUNDS)

For necessary expenses, not otherwise provided for, in the conduct and support of exploration capabilities research and development activities, including research, development, operations, support and services; maintenance; construction of facilities including repair, rehabilitation, revitalization and modification of facilities, construction of new facilities and additions to existing facilities, facility planning and design, and acquisition or condemnation of real property, as authorized by law; environmental compliance and restoration; space flight, spacecraft control and communications activities including operations, production, and services; program management; personnel and related costs, including uniforms or allowances therefore, as authorized by 5 U.S.C. 5901-5902; travel expenses; purchase and hire of passenger motor vehicles; not to exceed \$35,000 for official reception and representation expenses; and purchase, lease, charter, maintenance and operation of mission and administrative aircraft, \$[8,425,850,000]6,763,000,000, to remain available until September 30, [2006] 2007, of which amounts as determined by the Administrator for salaries and benefits; training, travel and awards; facility and related costs; information technology services; science, engineering, fabricating and testing services; and other administrative services may be transferred to "Science, aeronautics and exploration" in accordance with section 312(b) of the National Aeronautics and Space Act of 1958, as amended by Public Law 106-377. (*Departments of Veterans Affairs and Housing and Urban Development, and Independent Agencies Appropriations Act, 2005.*)

## Proposed Appropriation Language

### OFFICE OF INSPECTOR GENERAL

For necessary expenses of the Office of Inspector General in carrying out the Inspector General Act of 1978, as amended, \$[31,600,000] 32,400,000.

### ADMINISTRATIVE PROVISIONS

Notwithstanding the limitation on the availability of funds appropriated for "Science, aeronautics and exploration", or "Exploration capabilities" by this appropriations Act, when any activity has been initiated by the incurrence of obligations for construction of facilities or environmental compliance and restoration activities as authorized by law, such amount available for such activity shall remain available until expended. This provision does not apply to the amounts appropriated for institutional minor revitalization and construction of facilities, and institutional facility planning and design.

Notwithstanding the limitation on the availability of funds appropriated for "Science, aeronautics and exploration", or "Exploration capabilities" by this appropriations Act, the amounts appropriated for construction of facilities shall remain available until September 30, [2007] 2008.

The unexpired balances of prior appropriations to National Aeronautics and Space Administration for activities for which funds are provided under this Act may be transferred to the new account established for the appropriation that provides such activity under this Act. Balances so transferred may be merged with funds in the newly established account and thereafter may be accounted for as one fund under the same terms and conditions but shall remain available for the same period of time as originally appropriated.

From amounts made available in this Act for these activities, subject to [the] operating plan [procedures of] *notification* to the House and Senate Committees on Appropriations, the Administrator may transfer amounts between the "Science, aeronautics, and exploration" account and the "Exploration capabilities" account.

Funds for announced prizes otherwise authorized shall remain available, without fiscal year limitation, until the prize is claimed or the offer is withdrawn. [Funding shall not be made available for Centennial Challenges unless authorized.]

### GENERAL PROVISIONS

*Sec. 414 "Notwithstanding 40 U.S.C. Sections 524, 571, and 572, the Administrator of National Aeronautics and Space Administration may sell the National Aeronautics and Space Administration-owned Property on the Camp Parks Military Reservation, Alameda County, California and credit the net proceeds of such sales as offsetting collections to its Science, Aeronautics, and Exploration account. Such funds shall be available until expended to be used to replace the facilities at Camp Parks that are still required and/or to improve other National Aeronautics and Space Administration-owned facilities."*

## Supporting Data: Reconciliation of Appropriations to Budget Requests

| (In Millions of Real Year Dollars)  | TOTAL           | Science,<br>Aeronautics<br>and<br>Exploration | Space<br>Flight<br>Capabilities | Inspector<br>General |
|---|-----------------|---|---------------------------------|----------------------|
| <b>FISCAL YEAR 2004 REQUEST</b>   | <b>15,469.3</b> | <b>7,660.9</b>                                | <b>7,782.1</b>                  | <b>26.3</b>          |
| Total FY 2004 Omnibus Appropriations Act, P.L. 108-199<br>(including application of a 0.59% rescission) | -91.3           | 169.3   | -261.4                          | 0.8                  |
| Transfers by NASA   | 0.0             | 42.4  | -42.4                           | —                    |
| <b>TOTAL FY 2004 BUDGET PLAN</b>  | <b>15,378.0</b> | <b>7,872.6</b>                                | <b>7,478.3</b>                  | <b>27.1</b>          |

| (In Millions of Real Year Dollars)  | TOTAL           | Science,<br>Aeronautics<br>and<br>Exploration | Exploration<br>Capabilities | Inspector<br>General |
|---|-----------------|---|-----------------------------|----------------------|
| <b>FISCAL YEAR 2005 REQUEST</b>   | <b>16,244.0</b> | <b>7,760.0</b>                                | <b>8,456.4</b>              | <b>27.6</b>          |
| Emergency Supplemental Appropriations for Hurricane<br>Disasters Assistance Act, 2005, included as part of the FY<br>2005 Military Construction Appropriations Act (P.L. 108-132) | 126.0           | —   | 126.0                       | —                    |
| FY 2005 Consolidated Appropriations Act, P.L. 108-447<br>(including application of a 0.80% rescission)  | -173.6          | -81.9   | -95.4                       | 3.7                  |
| Transfers by NASA (as of January 2005)  | 0.0             | 2.7   | -2.7                        | —                    |
| <b>TOTAL FY 2005 BUDGET PLAN</b>  | <b>16,196.4</b> | <b>7,680.9</b>                                | <b>8,484.2</b>              | <b>31.3</b>          |

**Supporting Data: FY 2004 Appropriation by Budget Line Item**

| <b>FY 2004 APPROPRIATION STRUCTURE</b>      | <b>Request</b>  | <b>9/28/2004<br/>Operating Plan</b> |
|---|-----------------|-------------------------------------|
| <b>SCIENCE, AERONAUTICS and EXPLORATION</b> | <b>7,660.9</b>  | <b>7,872.6</b>                      |
| Space Science                               | 4,007.1         | 3,992.0                             |
| Earth Science                               | 1,552.2         | 1,607.8                             |
| Biological and Physical Research            | 972.7           | 985.6                               |
| Aeronautics                                 | 959.1           | 1,056.8                             |
| Education Programs                          | 169.8           | 230.4                               |
| <b>SPACE FLIGHT CAPABILITIES</b>            | <b>7,782.1</b>  | <b>7,478.3</b>                      |
| Space Station                               | 1,707.1         | 1,363.7                             |
| Space Shuttle                               | 3,968.4         | 4,060.9                             |
| Space and Flight Support                    | 434.3           | 465.5                               |
| Crosscutting Technology                     | 1,672.3         | 1,588.2                             |
| <b>INSPECTOR GENERAL</b>                    | <b>26.3</b>     | <b>27.1</b>                         |
| <b>TOTAL AGENCY</b>                         | <b>15,469.3</b> | <b>15,378.0</b>                     |

Note: May not add due to rounding

## Supporting Data: Reimbursable Estimates

### Reimbursable Estimate by Appropriation

| Agency Activity (\$ in millions)     | FY 2004      | FY 2005        | FY 2006      |
|--------------------------------------|--------------|----------------|--------------|
| Human Space Flight                   | 43.0         | —              | —            |
| Science, Aeronautics and Technology  | 152.0        | —              | —            |
| Science, Aeronautics and Exploration | 550.0        | 664.0          | 485.0        |
| Exploration Capabilities             | 138.0        | 617.0          | 398.0        |
| <b>Total</b>                         | <b>883.0</b> | <b>1,281.0</b> | <b>883.0</b> |



## Supporting Data: Distribution of Funds by Installation

### Distribution of Funds by Installation

| (In millions of dollars)      |                  | FY 2005    | FY 2006    |
|-------------------------------|------------------|------------|------------|
| Ames Research Center          | Direct Personnel | 107        | 111        |
|                               | Direct Travel    | 5          | 5          |
|                               | Center G& A      | 120        | 191        |
|                               | Service Pools    | 51         | 37         |
|                               | Program CoF      | 0          | 0          |
|                               | <b>Total</b>     | <b>283</b> | <b>344</b> |
|                               | FTEs             | 1,375      | 1,297      |
| Glenn Research Center         | Direct Personnel | 144        | 147        |
|                               | Direct Travel    | 5          | 5          |
|                               | Center G& A      | 106        | 161        |
|                               | Service Pools    | 77         | 64         |
|                               | Program CoF      | 0          | 0          |
|                               | <b>Total</b>     | <b>332</b> | <b>377</b> |
|                               | FTEs             | 1,875      | 1,775      |
| Langley Research Center       | Direct Personnel | 131        | 135        |
|                               | Direct Travel    | 7          | 7          |
|                               | Center G& A      | 120        | 195        |
|                               | Service Pools    | 111        | 86         |
|                               | Program CoF      | 0          | 0          |
|                               | <b>Total</b>     | <b>368</b> | <b>423</b> |
|                               | FTEs             | 2,109      | 2,046      |
| Dryden Flight Research Center | Direct Personnel | 38         | 36         |
|                               | Direct Travel    | 2          | 2          |
|                               | Center G& A      | 37         | 40         |
|                               | Service Pools    | 31         | 29         |
|                               | Program CoF      | 0          | 0          |
|                               | <b>Total</b>     | <b>108</b> | <b>107</b> |
|                               | FTEs             | 568        | 527        |

## Supporting Data: Distribution of Funds by Installation

|                             |                  |            |            |
|-----------------------------|------------------|------------|------------|
| Goddard Space Flight Center | Direct Personnel | 232        | 243        |
|                             | Direct Travel    | 9          | 9          |
|                             | Center G& A      | 195        | 214        |
|                             | Service Pools    | 76         | 76         |
|                             | Program CoF      | 0          | 15         |
|                             | <b>Total</b>     | <b>511</b> | <b>557</b> |
|                             | FTEs             | 3,416      | 3,379      |
| Marshall Flight Center      | Direct Personnel | 162        | 155        |
|                             | Direct Travel    | 5          | 5          |
|                             | Center G& A      | 181        | 226        |
|                             | Service Pools    | 95         | 83         |
|                             | Program CoF      | 18         | 52         |
|                             | <b>Total</b>     | <b>461</b> | <b>521</b> |
|                             | FTEs             | 2,657      | 2,509      |
| Stennis Space Center        | Direct Personnel | 17         | 13         |
|                             | Direct Travel    | 1          | 1          |
|                             | Center G& A      | 47         | 40         |
|                             | Service Pools    | 23         | 22         |
|                             | Program CoF      | 3          | 7          |
|                             | <b>Total</b>     | <b>90</b>  | <b>83</b>  |
|                             | FTE's            | 311        | 280        |
| Johnson Space Center        | Direct Personnel | 284        | 311        |
|                             | Direct Travel    | 14         | 15         |
|                             | Center G& A      | 192        | 207        |
|                             | Service Pools    | 186        | 198        |
|                             | Program CoF      | 1          | 4          |
|                             | <b>Total</b>     | <b>678</b> | <b>735</b> |
|                             | FTEs             | 3,234      | 3,270      |

**Supporting Data: Distribution of Funds by Installation**

|                           |                  |            |            |
|---------------------------|------------------|------------|------------|
| Kennedy Space Center      | Direct Personnel | 113        | 122        |
|                           | Direct Travel    | 6          | 6          |
|                           | Center G&A       | 242        | 232        |
|                           | Service Pools    | 105        | 111        |
|                           | Program CoF      | 33         | 39         |
|                           | <b>Total</b>     | <b>498</b> | <b>510</b> |
|                           | FTEs             | 2,125      | 2,144      |
| Jet Propulsion Laboratory | N/A since FFRDC  |            |            |

## Supporting Data: Civil Service Distribution

### Civil Service Distribution of Full Time Equivalents

The civil service workforce is the underpinning for the successful accomplishment of the Nation's civil aeronautics and space programs. These are the people who plan the programs; conduct and oversee the research; select and monitor the contractors; manage the various research, development, and test activities; and oversee all of NASA's operations. A key dimension of the reinvention of NASA has been the restructuring of the civil service workforce to deliver a space and aeronautics program that is balanced, relevant, and at the forefront of technology development.

NASA's primary goals for its civil service workforce are to:

- Acquire and maintain a civil service workforce reflecting the cultural diversity of the Nation; and
- Provide a workforce, sized and skilled as needed, to accomplish NASA's research, development, and operational missions with innovation, excellence, and efficiency.

### Civil Service Distribution Detail

| Full Time Equivalents (FTEs)  | FY 2004       | FY 2005       | FY 2006       |
|-------------------------------|---------------|---------------|---------------|
| Ames Research Center          | 1,444         | 1,375         | 1,297         |
| Dryden Flight Research Center | 567           | 568           | 527           |
| Glenn Research Center         | 1,905         | 1,875         | 1,775         |
| Goddard Space Flight Center   | 3,260         | 3,416         | 3,379         |
| Headquarters                  | 1,317         | 1,557         | 1,571         |
| Johnson Space Center          | 2,994         | 3,234         | 3,270         |
| Kennedy Space Center          | 1,867         | 2,125         | 2,144         |
| Langley Research Center       | 2,286         | 2,109         | 2,046         |
| Marshall Space Flight Center  | 2,699         | 2,657         | 2,509         |
| Stennis Space Center          | 294           | 311           | 280           |
| <b>Total</b>                  | <b>18,633</b> | <b>19,227</b> | <b>18,798</b> |

**Summary of Consulting Services**

NASA uses paid experts and consultants to provide NASA with advice and expert input in addition to or beyond that available from its in-house civil service workforce. NASA also uses experts and consultants to provide expert advice and input on the selection of experiments for future space missions. The use of these experts and consultants, in addition to NASA civil service personnel, provides the Agency with an independent view that assures the selection of experiments likely to have the greatest scientific merit. Other individuals are used to provide independent analysis of technical and functional problems in order to give top management the widest possible range of views before making major decisions.

NASA-established management controls assure that consulting services arrangements are both justified and approved at top management levels before any action is taken.

| <b>Expert/Consultants (Total NASA)</b> | <b>FY 2004</b>   | <b>FY 2005</b>   | <b>FY 2006</b>   |
|--|------------------|------------------|------------------|
| Number of Paid Experts and Consultants | 39               | 50               | 50               |
| Annual FTE Usage                       | 4                | 4                | 4                |
| Salaries                               | \$449,800        | \$458,796        | \$467,972        |
| Total Salary and Benefits Costs        | \$484,210        | \$493,894        | \$503,772        |
| Travel Costs                           | \$463,509        | \$477,414        | \$491,737        |
| <b>Total Costs</b>                     | <b>\$947,719</b> | <b>\$971,308</b> | <b>\$995,509</b> |

## Supporting Data: Construction of Facilities

### Summary of Resources Included in Budget Request

| In Millions of Dollars                          | FY 2004             | FY 2005             | FY 2006             |
|---|---------------------|---------------------|---------------------|
| <b>Total Construction of Facilities</b>         | <b><u>240.4</u></b> | <b><u>202.5</u></b> | <b><u>292.7</u></b> |
| Science, Aeronautics and Exploration Programs*  | —                   | —                   | 35.0                |
| Exploration Capabilities Programs*              | 55.0                | 54.8                | 75.8                |
| Non-Programmatic Programs (included within G&A) | 185.4               | 147.7               | 181.9               |

\* FY 2004 data shown mapped to the new FY 2005/2006 appropriation accounts.

The Construction of Facilities (CoF) program ensures that the facilities critical to achieving NASA's space and aeronautics programs are the right size and type, and that they are safe, secure, environmentally sound, and operated efficiently and effectively. It also ensures that NASA installations conform to requirements and initiatives for the protection of the environment and human health. NASA facilities are essential to the Agency and facility revitalization is needed to maintain infrastructure that is safe and capable of supporting NASA's missions. The facilities being revitalized or constructed in this program are expected to remain active in the long term and are consistent with current and anticipated Agency roles and missions, although some adjustments may be required to reflect recommendations of the Real Property Mission Analysis (RPMA), which should be complete in 2005. The RPMA is an independent, top-down, Mission-driven process to: identify the physical plants needed to support NASA's Mission and programs, identify shortages and excesses, and make recommendations regarding the disposition of excesses to ensure that NASA owns and maintains only essential real property.

Funding for construction projects required for specific programs is included in the appropriate budget line item within each Mission Directorate. Non-Programmatic CoF projects are required for components of NASA's basic infrastructure and institutional facilities. Funding for Non-Programmatic CoF projects identified to specific Centers has been included in that Center's General and Administrative (G&A) rate, and agency-wide initiatives are included as part of Corporate G&A. Descriptions and cost estimates of both non-programmatic and programmatic (or "program direct") projects are provided to show a complete picture of NASA's budget requirement for facilities revitalization and construction.

The institutional facility projects requested for FY 2006 continue the vital rehabilitation, modification, and repair of facilities to renew and help preserve and enhance the capabilities and usefulness of existing facilities and ensure the safe, economical, and efficient use of NASA's physical plants. The projects repair and modernize deteriorating and obsolete building and utility systems that have reached or exceeded their normal design life, are no longer operating effectively or efficiently, and cannot be economically maintained. These projects include mechanical, structural, cooling, steam, electrical distribution, sewer, and storm drainage systems. Some projects replace substandard facilities in cases where it is more economical to demolish and rebuild than it is to restore. Projects between \$0.5 million and \$5.0 million are included as Minor Revitalization and Construction projects, and projects with an estimated cost of at least \$5.0 million are budgeted as Discrete projects. (Projects less than \$0.5 million are accomplished by routine day-to-day facility maintenance and repair activities provided for in direct program and Center operating budgets.) Should residual resources become available from any Minor Revitalization or Discrete project, they will be used for urgently needed facility revitalization requirements and Congress will be notified before work is initiated for any such Discrete projects. Funds requested for Facility Planning and Design (FP&D) cover: advance planning and design requirements for future projects; preparation of facility project design drawings and bid specifications; master planning; facilities studies; engineering reports and studies; and critical functional leadership activities directed at increasing the rate of return of constrained Agency resources while keeping the facility infrastructure safe, reliable, and available.

## Supporting Data: Construction of Facilities

### Summary of FY 2006 "Program-Direct" CoF Projects

| In Millions of Dollars   | FY 2004            | FY 2005            | FY 2006            |
|--|--------------------|--------------------|--------------------|
| <b><u>SCIENCE, AERONAUTICS &amp; EXPLORATION COF PROJECTS</u></b>                    | <b><u>0.0</u></b>  | <b><u>0.0</u></b>  | <b><u>35.0</u></b> |
| <u>SCIENCE</u>   | <u>0.0</u>         | <u>0.0</u>         | <u>35.0</u>        |
| Construct Space Science Building, Phase 1 (GSFC)                                     | —                  | —                  | 15.0               |
| Construct Flight Project Center, Phase 1 (JPL)                                       | —                  | —                  | 20.0               |
| <b><u>EXPLORATION CAPABILITIES COF PROJECTS</u></b>                                  | <b><u>55.0</u></b> | <b><u>54.8</u></b> | <b><u>75.8</u></b> |
| <u>SPACE OPERATIONS (SPACE SHUTTLE)</u>  | <u>53.9</u>        | <u>53.6</u>        | <u>74</u>          |
| Repairs to Launch Complex LC-39B (KSC)   | —                  | —                  | 22.8               |
| Repairs to Vehicle Assembly Building (KSC)   | —                  | 23.5               | 9.4                |
| Repairs to Launch Complex LC-39A (KSC)   | 19.8               | —                  | —                  |
| Replace Roof, Vehicle Assembly Building (KSC)  | 17.0               | —                  | —                  |
| Minor Revitalization of Facilities at Various Locations (less than \$5M per project) | 14.6               | 25.8               | 40.5               |
| Facility Planning and Design   | 2.5                | 4.3                | 1.3                |
| <u>SPACE OPERATIONS (SPACE &amp; FLIGHT SUPPORT)</u>                                 | <u>1.1</u>         | <u>1.2</u>         | <u>1.8</u>         |
| Minor Revitalization of Facilities at Various Locations (less than \$5M per project) | .9                 | .9                 | 1.5                |
| Facility Planning and Design   | 0.2                | 0.3                | 0.3                |

### Summary of FY 2006 Non-Programmatic CoF Projects

| In Millions of Dollars   | FY 2004             | FY 2005             | FY 2006             |
|--|---------------------|---------------------|---------------------|
| <b><u>NON-PROGRAMMATIC PROJECTS*</u></b>                                       | <b><u>185.4</u></b> | <b><u>147.7</u></b> | <b><u>181.9</u></b> |
| Rehabilitate Electrical Distribution System (ARC)                              | —                   | —                   | 5.0                 |
| Repair Emergency Chiller System, Building 24 (GSFC)                            | —                   | —                   | 5.7                 |
| Construct Administrative and Education Complex, Phase 1 (JPL)                  | —                   | —                   | 22.5                |
| Seismic Upgrade of Telecommunications Building, B238 (JPL)                     | —                   | —                   | 6.0                 |
| Renovation of Operations and Checkout Building (KSC)                           | —                   | —                   | 5.4                 |
| Upgrade Electrical Power Distribution (LaRC)                                   | —                   | —                   | 6.7                 |
| Seismic Upgrade of Building B180 (JPL)   | —                   | 5.0                 | —                   |
| Construct Replacement for Fire Station No. 2 at Shuttle Landing Facility (KSC) | —                   | 6.4                 | —                   |
| Consolidate Business Functions into Building 1194 (LaRC)                       | —                   | 9.5                 | —                   |
| Construct First Response Facility (SSC)  | —                   | 6.0                 | —                   |
| Construct Astronaut Quarantine Facility (JSC)                                  | 1.2                 | —                   | —                   |
| Rehabilitate and Upgrade Electrical and Mechanical Systems (24) (JSC)          | 5.5                 | —                   | —                   |
| Repair/Replace 350psig Steam Distribution System, Utility Tunnel No. 4 (LaRC)  | 9.2                 | —                   | —                   |
| Construct Replacement Office Building, 4600 Area (MSFC)                        | 15.7                | —                   | —                   |

## Supporting Data: Construction of Facilities

| In Millions of Dollars  | FY 2004 | FY 2005 | FY 2006 |
|---|---------|---------|---------|
| <u>NON-PROGRAMMATIC PROJECTS* continued</u>   |         |         |         |
| Development of Stennis Visitor Center (SSC)   | 0.9     | —       | —       |
| Construct Consolidated Engineering Building (WFF)                                       | 9.0     | —       | —       |
| Minor Revitalization and Construction at Various Locations (less than \$5M per project) | 117.0   | 94.2    | 105.1   |
| Facility Planning and Design  | 17.0    | 16.6    | 16.5    |
| Demolition of Facilities  | 9.9     | 10.0    | 9.0     |

Note: Funding for Non-Programmatic CoF identified to specific Centers has been included in that Center's G&A rate and Agency-wide initiatives are included within Corporate G&A.

### Discrete Projects within the Science, Aeronautics and Exploration Account

#### ***Space Science Program***

Project Title: Construct Space Science Building

Location: Goddard Space Flight Center (GSFC), Greenbelt, MD

Mission Directorate: Science

FY 2006 Estimate: \$15.0M

This project will construct a new 235,000 square-foot laboratory and office building at the Greenbelt site. The facility will provide a state-of-the-art laboratory, support, and office space for 750 scientists. The new facility will consolidate science work groups and is expected to increase work efficiency and scientific collaboration. The new facility will replace the 44-year-old Research Projects Laboratory building and the 37-year-old Space Science Data Center building. These facilities must be replaced because the electrical and mechanical systems have become unreliable; impacting science functions. The buildings require extensive repairs, and have high energy and operating costs. The new Space Science Building will incorporate energy-reducing and environmentally-friendly features that will reduce overall operating costs and generate a cost savings over the life of the facility. This is the first of three phases with a total estimated cost of \$65 million for the project with completion planned in FY 2008.

Project Title: Construct Flight Project Center

Location: Jet Propulsion Laboratory (JPL), Pasadena CA

Mission Directorate: Science

FY 2006 Estimate: \$20.0M

This project will construct a new 17,000 square-meter six-story building to provide office space plus conference and support facilities for approximately 625 people. The new facility will co-locate the program and project staffs for flight projects into a single building. The building will contain a separate 400 fixed-seat sloped-floor Project Review Center to host large project reviews and JPL institutional meetings, as well as a 200 moveable-seat flat-floor conference room that will be divisible into four 50 seat conference rooms. Expensive off-site leased space will be vacated and the need for additional off-site leases will be avoided. Six 1940's vintage buildings and 44 wooden trailers will be demolished. The Center will provide the means to collocate essential flight project personnel into a single location for a true teaming environment. This will: increase project development efficiency; enhance communications; allow sharing of common resources; enable more efficient dissemination



of lessons learned among projects; and enhance the ability of experts to support multiple program/project functions. This is the first of two phases with a total estimated cost of \$41 million with completion planned in FY 2007.

### **Discrete Projects within the Exploration Capabilities Account**

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#### ***Space Shuttle Program***

Project Title: Repairs to Launch Complex LC-39B

Location: Kennedy Space Center (KSC), Merritt Island, FL

Mission Directorate: Space Operations

FY 2006 Estimate: \$22.8M

This project provides for the complete repair and refurbishment of Launch Complex 39B (LC-39B). LC-39B consists of the Fixed Service Structure (FSS) tower, which is approximately 300 feet tall and 40 feet square with a central core containing two elevators, and the Rotating Service Structure (RSS) tower, which is approximately 130 feet tall and 52 feet square. The Orbiter Weather Protection (OWP) system, and Payload Change-out Room (PCR) are integral parts of these tower structures. This project removes and replaces corrosion damaged structural members and connections on the FSS and on the RSS at LC-39B. RSS drive truck assemblies and rail systems will be repaired. Existing deteriorated panels on the PCR will be replaced with corrugated stainless steel sandwich insulated panels. Mechanical and electrical wall penetrations will be removed and rerouted through new centralized bulkhead plates. Orbiter Weather Protection will be upgraded to harden enclosures against weather and launch environments. New controls will be installed to operate weather curtains and struts. The project will perform corrosion control and seal the LC-39B structure with inorganic zinc coating. The project also includes modifications to improve safe access for operations, maintenance, future inspections and corrosion protection where practical. All abandoned equipment, structural elements, supports, lines, and associated hardware shall be removed. Mechanical, electrical and control systems will be upgraded. An enhanced wash-down system will be installed to protect the Orbiter from environmental contaminants while on the launch pad. The flame deflector and flame trench will be refurbished. Concrete surfaces, slopes and concrete structural beams on LC-39B will be repaired, reinforced and sealed. Other associated minor repairs, modification and upgrades will be accomplished as required.

Project Title: Repairs to Vehicle Assembly Building

Location: Kennedy Space Center (KSC), Merritt Island, FL

Mission Directorate: Space Operations

FY 2006 Estimate: \$9.4M

This project will repair and refurbish several of the Vehicle Assembly Building (VAB) systems and mechanisms. Secondary power systems and switch-gear will be revitalized. Fire extinguishing systems for the extensible platform in high-bay 3 will be upgraded. VAB systems are significantly deteriorated as a result of 40 years of operational use and the corrosive environment at the Kennedy Space Center. VAB mechanical and electrical systems have become unreliable. In some cases, system components are obsolete and replacement parts are no longer available. Failure to complete VAB repairs could lead to loss of flight hardware in VAB, and increased risk of injury to personnel. This is the third phase of a five-phase program of VAB system revitalization, and is estimated to cost a total of \$73 million and be completed in 2008.

## Supporting Data: Construction of Facilities

### FY 2006 Non-Programmatic Construction of Facilities

| In Millions of Dollars  | FY 2004             | FY 2005             | FY 2006             |
|---|---------------------|---------------------|---------------------|
| <b><u>Total Non-Programmatic Construction of Facilities</u></b> | <b><u>185.4</u></b> | <b><u>147.7</u></b> | <b><u>181.9</u></b> |
| Discrete Projects   | 41.5                | 26.9                | 51.3                |
| Minor Revitalization and Construction                           | 117.0               | 94.2                | 105.1               |
| Facility Planning and Design                                    | 17.0                | 16.6                | 16.5                |
| Demolition  | 9.9                 | 10.0                | 9.0                 |

#### Non-Programmatic Discrete Projects

Project Title: Rehabilitate Electrical Distribution System

Location: Ames Research Center (ARC), Moffett Field, CA

FY 2006 Estimate: \$5.0M

This project will modernize and repair the Center's primary electrical distribution system as part of a phased program to improve reliability. Medium voltage switchgear and transformers will be replaced with new medium voltage switchgear, circuit breakers, and transformers. New microprocessor-based protective relays, and current and potential transformers will be used to allow connection to the new Ames Power Monitoring System. The existing 1945 vintage, Center-wide electrical system is worn out and unreliable. As a result, Ames has experienced increasing instances of power interruptions that have adversely impacted critical research. The old switchgear is unsafe to operate, and it is difficult to maintain because replacement parts are no longer available. This is the fifth of approximately twelve phases estimated to cost a total of \$63 million with completion planned in FY 2014.

Project Title: Repair Emergency Chiller System, Building 24

Location: Goddard Space Flight Center (GSFC), Greenbelt, MD

FY 2006 Estimate: \$5.7M

This project replaces chillers, cooling towers, heat exchangers and associated mechanical and electrical equipment of the emergency chilled water system, located in Building 24. Replacing the equipment while maintaining emergency chiller service will require installation of new equipment in a 2,000 square foot building extension. The Emergency Chilled Water System comprises part of the Goddard critical infrastructure. The system provides emergency chilled water to critical facilities at the Greenbelt site in the event of a power failure. The chillers provide cooling for computers supporting Hubble Space Telescope service, testing and emergency control as well as operations and data acquisition for: Solar and Heliospheric Observatory (SOHO), High Energy X-Ray Timing Experiment (XTE), Microwave Anisotropy Probe (MAP), and other missions. The emergency chilled water system also provides cooling to computers supporting NASA-wide voice distribution for manned space missions. Failure of the emergency chilled water system would put these programs at risk during a power failure. The current chillers and equipment are 21 years old and have experienced multiple failures in the past two years. Replacement is necessary to provide reliable emergency chilled water to critical systems in the case of a power failure. This is the first of two phases to complete the project in FY 2007. The total estimated cost for both phases is \$9 million.

## Supporting Data: Construction of Facilities

Project Title: Construct Administrative and Education Center Complex

Location: Jet Propulsion Laboratory (JPL), Pasadena, CA

FY 2006 Estimate: \$22.5M

This project replaces the current Administration Building (Building 180) and visitor control and education facilities with a new Administrative and Education Center Complex. This project will provide office, conference, and support facilities for approximately 220 people currently housed in Building 180. A new 4,200 square-meter (45,000 square feet) Education Center will be constructed to include a sloped-floor theater/auditorium, three conference rooms, a two-story exhibit hall, a visitor badging lobby, a video/teleconference room, a conference/demonstration room, a teaching resource classroom, and a one-story exhibit space. Parking spaces to support the new complex are included. Building 180 is deficient in its ability to resist a major seismic event. It is more economical to replace than to upgrade the building for seismic safety due to the inherent design of the structure, inefficiency in space utilization, extent of asbestos fireproofing, age of the building and its support systems, and non-conformance with contemporary life-safety and accessibility codes and regulations. The Education Center will support JPL's role in carrying out the initiatives of NASA's Office of Education by providing space and facilities for conferences, data and images distribution, exhibits and displays, public outreach events, and other meetings that bring members of the educational community, the media, and the general public to JPL. This is consistent with part of NASA's Mission to educate the public. This is the first of two phases with an estimated total construction cost of \$49 million. Completion is planned for FY 2007

Project Title: Seismic Upgrade of Telecommunications Building, B238

Location: Jet Propulsion Laboratory (JPL), Pasadena, CA

FY 2006 Estimate: \$6.0M

This project upgrades the Telecommunications Building to increase its ability to withstand a major seismic event. The building's structural framing will be strengthened to meet current life-safety standards for structures in this high seismic zone. The strengthening will consist of new perimeter steel braced frames to be attached to the existing exterior floor beams and its footings will be tied into the existing building foundations. Asbestos abatement will be done in areas affected by this repair work. A detailed structural analysis revealed that the building does not satisfy current life-safety provisions for this type of structure in a high seismic zone.

Project Title: Renovation of Operations and Checkout Building

Location: Kennedy Space Center (KSC), Merritt Island, FL

FY 2006 Estimate: \$5.4M

This project revitalizes the Operations and Checkout Building for indoor air quality, energy efficiency and life safety compliance in various locations. The revitalization will consist of installing a sprinkler system, energy-efficient office lighting, complete updating of the Heating, Ventilation, and Air Conditioning (HVAC) systems and demolishing the existing HVAC ductwork that contributes to poor indoor air quality. Asbestos abatement will also be included. Other facility systems include HVAC controls, lighting and fire protection. This phase will include the demolition and renovation of a portion of the North Wing. In addition, this project will upgrade employees' office areas, including power, communications and data systems. A critical need exists at the Kennedy Space Center to revitalize substandard housing affecting the health, safety and welfare of personnel. The deteriorated substandard housing is contributing to costly maintenance needs, highly inefficient energy consumption and unhealthy working environments. The facility has not been updated to

## Supporting Data: Construction of Facilities

current Florida Building Codes, Florida Fire Prevention Codes, or National Fire Protection Association Life Safety Standards. This project will relieve personnel of the health dangers associated with poor Indoor Air Quality and Building Related Illnesses. An increase in space utilization will be realized. This is the first of six phases with a total estimated construction cost of \$37 million and completion planned for FY 2011.

Project Title: Upgrade Electrical Power Distribution

Location: Langley Research Center (LaRC), Hampton, VA

FY 2006 Estimate: \$6.7M

This project replaces old electrical equipment including transformers and switchgear. The switchgear is 1950's and 1960's vintage technology and is failing. The transformers are more than 20 years old and past their useful life. Operations and maintenance costs to keep this outdated system running are high and continually increasing. This is the first of seven phases. The total estimated cost of all phases is \$33.5 million. Completion of this project is planned for FY 2010.

### Minor Revitalization and Construction of Facilities (projects less than \$5.0M each)

|   | <u>Institutional<br/>Support</u> | <u>Exploration<br/>Capabilities</u> |
|---|----------------------------------|-------------------------------------|
| <u>FY 2006 Estimate (Millions of Dollars)</u> | <u>105.1</u>                     | <u>42.0</u>                         |
| Ames Research Center                          | 6.5                              |                                     |
| Dryden Flight Research Center                 | 2.9                              |                                     |
| Glenn Research Center                         | 7.6                              |                                     |
| Goddard Space Flight Center                   | 10.3                             |                                     |
| Jet Propulsion Laboratory                     | 12.6                             |                                     |
| Johnson Space Center                          | 19.7                             | 3.5                                 |
| Kennedy Space Center                          | 12.3                             | 4.9                                 |
| Langley Research Center                       | 11.9                             |                                     |
| Marshall Space Flight Center                  | 12.9                             | 26.5                                |
| Stennis Space Center                          | 8.4                              | 7.1                                 |

This request includes facility revitalization and construction needs greater than \$0.5 million but less than \$5.0 million per project. Projects \$0.5 million and less are normally accomplished by routine day-to-day facility maintenance and repair activities provided for in direct program and Center operating budgets. Proposed FY 2006 Non-Programmatic projects total \$105.1 million for components of the basic infrastructure and institutional facilities, and \$42.0 million for specific Exploration Capabilities projects. These resources provide for revitalization and construction of facilities at NASA field installations and government-owned industrial plants supporting NASA activities. Revitalization and modernization projects provide for the repair, modernization, and/or upgrade of facilities and collateral equipment. Repair projects restore facilities and components to a condition substantially equivalent to the originally intended and designed capability. Repair and modernization work includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. It also includes major preventive measures that are normally accomplished on a cyclic schedule and those quickly needed out-of-cycle based on adverse condition information revealed during predictive testing and inspection efforts. Modernization and upgrade projects include both restoration of current functional

## Supporting Data: Construction of Facilities

capability and enhancement of the condition of a facility so that it can more effectively accomplish its designated purpose or increase its functional capability or so that it can meet new building, fire, and accessibility codes.

The minor revitalization and construction projects that comprise this request are of the highest priority, based on relative urgency and expected return on investment. The titles of the projects are designed to identify the primary intent of each project and may not always capture the entire scope or description of each project. Also, during the year, some rearrangement of priorities may be necessary which may cause a change in some of the items to be accomplished.

### **Non-Programmatic Minor Revitalization Programs: \$105.1 million**

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#### **A. Ames Research Center (ARC), \$6.5 million for the following:**

1. Legionella Mitigation, Buildings N10, N200, N207A, N212, N230, N238, and N248
2. Modify Fire Exits and Safety Egress, Buildings N226, N244, N248, and N16
3. Seismic Upgrades, Buildings N201, N223, N240
4. Rehabilitate and Modify 20 MW Power Supply, Phase IV
5. Rehabilitate and Modify Fire Suppression System, Buildings N200, N226, N244, N256, N16
6. Rehabilitate and Modify Fire Suppression System, Buildings N207, N247, N260, N261, N10, N510

#### **B. Dryden Flight Research Center (DFRC), \$2.9 million for the following:**

1. Repair Primary Electrical Distribution Systems, Phase 4
2. Repair Hangar B-4826

#### **C. Glenn Research Center (GRC), \$7.6 million for the following:**

1. Repair Parking Lots and Roads, Various Locations, Phase 2
2. Rehabilitate Engineering Building 7141, Plum Brook Station, Phase 2
3. Modify Fire Alarms and Sprinklers for Life Safety, Various Buildings
4. Repair Water System, Plum Brook Station, Phase 2

#### **D. Goddard Space Flight Center (GSFC), \$10.3 million for the following:**

1. Modify Various Buildings for Accessibility, Wallops Flight Facility (WFF)
2. Safety Upgrades to Runway 10-28, Phase 2, WFF
3. Modernize Magnetic Test Facility, Area 300
4. Upgrade Information Technology Facilities Environmental Control, Building 5, Phase 2
5. Site Utilities for Implementation of Master Plan
6. Repair Roofs, Various Buildings
7. Replace Septic Systems, WFF

#### **E. Jet Propulsion Laboratory (JPL), \$12.6 million for the following:**

1. Repair Spacecraft Assembly Facility, B179, Phase 1
2. Replace Obsolete Power Control Center, Building 230
3. Remodel Cafeteria Building 303
4. Purchase and Improve Forestry Camp Road
5. Replace Liquid Nitrogen Storage Tanks, Phase 2
6. Upgrade HVAC Systems in Buildings 168 and 169

## Supporting Data: Construction of Facilities

### **F. Johnson Space Center (JSC), \$19.7 million for the following:**

1. Replace Roofs, Various Buildings (7, 15)
2. Upgrade Central Plant and Rehabilitate Plant Equipment (24)
3. Refurbish Public Affairs Facility (2 North)
4. Upgrade/Rehabilitate Electrical Substation & Distribution Sys, Sony Carter Training Facility
5. Repair Sanitary Sewer System, Ellington Field
6. Repair Sprinkler and Fire Alarm Systems, Phase 1
7. Rehabilitate Mission Simulation Development Facility (35)
8. Rehabilitate Exchange Facilities, Phase II (3, 11, 207)
9. Replace Roofs, Various Buildings (13)
10. Replace Loggia Ledge Coatings, Various Buildings
11. Upgrade Domestic Water Systems, Various Buildings
12. Repair Site Roofs, White Sands Test Facility, Phase 2

### **G. Kennedy Space Center (KSC), \$12.3 million for the following:**

1. Repair Industrial Area Support Building, M6-493
2. Upgrade Facilities for Disabled Access, Various Locations
3. Replace Life Support Facility
4. Revitalize and Upgrade KSC Water and Waste Water Systems, Various Locations
5. Replace Critical Transformers, Industrial and LC-39 Areas, Phase 2
6. Replace High Voltage Substations at M7-505
7. Install Optical Fire Detection Systems, Various Locations
8. Revitalize Cable and Duct Distribution, Industrial Area, Phase 3
9. Upgrade Primary Power System, M6-0409

### **H. Langley Research Center (LaRC), \$11.9 million for the following:**

1. Upgrade Facilities for Disabled Access, Various Locations, Phase 2
2. Rehabilitate Building 1192 D & E
3. Rehabilitate Elevators, Various Facilities
4. Refurbish Building 645A
5. Enhanced High Pressure Air Capability for National Transonic Facility, B1236
6. Repair Steam Condensate Return System in Tunnels

### **I. Marshall Space Flight Center (MSFC), \$12.9 million for the following:**

1. Replace HVAC and Electrical Equipment (4570)
2. Replace Asbestos Siding and Provide Energy/Safety Upgrades to Building Systems (4705), Phase 1
3. Replace & Upgrade Control Systems for Bridge Cranes (Site Wide), Phase 4
4. Energy Upgrades to Central Chiller Plant (4473)
5. Construct Additional Bays, Phase 1

### **J. Stennis Space Center, \$8.4 million for the following:**

1. Relocation of Stennis Visitors Center
2. Repair 120/208V Power Distribution, Sitewide Phase 2
3. Repairs to Roofing (1103, 1105, 2201, 8110)
4. Repairs to Administration Area Heating System
5. Restoration of Fire Alarm Systems, Phase 5
6. Repairs to 13.8kV Unit Substations in the Test Complex

**Exploration Capabilities Minor Revitalization Programs: \$42.0 million**

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**A. Johnson Space Center (JSC), \$3.5 million for the following:**

1. Replace Fire Detection System, Building 30S (Shuttle)
2. Rehabilitate Small Altitude Simulation System Steam Line, 300 and 400 Areas, WSTF (Shuttle)

**B. Kennedy Space Center (KSC), \$4.9 million for the following:**

1. Renovate HVAC System Building 836, Vandenberg Launch Site (Space and Flight Support)
2. Upgrade OPF-1 & 2 Fire Extinguishing (Firex) Water Systems (Shuttle)
3. Refurbish Roll up Doors, Rotating Payload Servicing Facility (RPSF) Surge Building

**C. Marshall Space Flight Center (MSFC), \$26.5 million for the following:**

1. Rehabilitate Controls, Cranes & Trolleys, Building 103, Phase 1, Michoud Assembly Facility (MAF) (Shuttle)
2. Replace Roof, Building 303, MAF (Shuttle)
3. Rehabilitate Waste Water Process Tanks, Phase 1, MAF (Shuttle)
4. Replace Air Handling Units (AHUs) 14, 17, 20, 25 & 26, Building 114, MAF (Shuttle)
5. Enhance Chemical Clean Line Facility, Building 103, MAF (Shuttle)
6. Replace Substation #46 & MCC, Building 131, MAF (Shuttle)
7. Install Closed Loop Chilled Water System, Building 103, Phase 2, MAF (Shuttle)
8. Replace Fire Alarm Systems, Phase 2, MAF (Shuttle)
9. Rehabilitate Cranes & Trolleys / Controls, Building 103, Phase 2, MAF (Shuttle)
10. Rehabilitate North Mezzanine, Building 103, MAF (Shuttle)
11. Replace Breathing /Air Compressors, Building 318, MAF (Shuttle)
12. Repair Roads and Parking Lots, Mars Drive and Building 103/318/350/351, MAF (Shuttle)

**D. Stennis Space Center (SSC), \$7.1 million for the following:**

1. Repair and Modernize SSME A-2 Test Stand, Phase 6 (Shuttle)
2. Refurbish High Pressure Industrial Water Pumps, Phase 3 (Shuttle)
3. Repairs to Cryogenic Barge Docks, Mooring Dolphins and Rolling Devices, (Shuttle)
4. Upgrades to Shuttle Infrastructure; Electrical Distribution (Shuttle)

**Facility Planning and Design (FP&D)**

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Cognizant Office: Office of Infrastructure, Management and Headquarters Operations

FY 2006 Estimate: \$16.5M

These funds are required to provide for: advance planning and design activities; special engineering studies; facility engineering research; preliminary engineering efforts required to initiate design-build projects; preparation of final designs, construction plans, specifications, and associated cost estimates; and participation in facilities-related professional engineering associations and organizations. These resources provide for project planning and design activities associated with non-programmatic construction projects. Project planning and design activities for construction projects required to conduct specific Exploration Capabilities or Science, Aeronautics and Exploration programs or projects are included in the appropriate budget line item. Other activities

## Supporting Data: Construction of Facilities

funded include: master planning; value engineering studies; design and construction management studies; facility operation and maintenance studies; facilities utilization analyses; engineering support for facilities management systems; and capital leveraging research activities.

### Demolition of Facilities

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Cognizant Office: Office of Infrastructure, Management and Headquarters Operations

FY 2006 Estimate: \$9.0M

The amount requested is required to fund major demolition projects Agency-wide. NASA owns over 2,800 buildings, and over 2,600 other structures, totaling almost 44 million square feet with a current replacement value of over \$20 billion. About two million square feet of these facilities are "mothballed" or "abandoned," another million square feet are to be closed in the next four years, and possibly more will be identified for closure due to an upcoming NASA Real Estate Strategic Review. Closed facilities are a drain on NASA resources, deteriorate into eyesores and possible safety hazards, and should be demolished.



### Purpose

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The goal of the Integrated Financial Management Program (IFMP) is to improve the financial, physical, and human resources management processes throughout the Agency. IFMP will re-engineer NASA's business infrastructure in the context of industry "best practices" and implement enabling technology to provide the necessary management information to support the Agency's Strategic Plan implementation.

### Overview

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Several projects are currently being managed by IFMP. The Core Financial Project, NASA's first fully integrated financial management system, was implemented in FY 2003 at all ten Centers. This system provides Agency-wide visibility of financial information to facilitate the decision-making process, thereby improving information exchange with customers and stakeholders. This system supports the Agency's implementation of full cost accounting, and the Agency's goal of "getting to Green" in Financial Performance within the President's Management Agenda (PMA). The Resume Management (RM) Project, implemented in FY 2002, introduced a new process and system that has changed how Human Resources offices fulfill their recruiting and staffing responsibilities. In 2004, we began modifying the RM system to support the e-Gov initiative, Recruitment One Stop. The Position Description Management Project, completed in September 2002, enables users to rapidly prepare and classify Position Descriptions (PDs). The Travel Management Project, completed in FY 2003 implemented a standardized, integrated travel management system that provides electronic routing, e-mail, and timely travel information. The Agency will be migrating to the eGov travel initiative beginning in FY 2006. Future projects include Project Management Information Improvement, Labor Distribution, Integrated Asset Management (IAM), Contract Management Module (CMM), and an upgrade to the existing financial system. The budget runout has been modified to focus on the development and implementation costs of the program. In the FY 2006 budget, deployment of all modules was planned to be completed in FY 2007, however, subsequent Agency requirements, priorities, and funding reductions are expected to impact the schedule and extend the implementation. The funds to cover the FY 2007 and out costs were initially budgeted to support the transfer of IFMP to the NASA Shared Services Center for sustainment. These funds are within the Corporate G&A funding levels and, therefore, do not represent additional costs to the Agency. With respect to GAO reports related to NASA's Integrated Financial Management Program, actions have been completed for most of the GAO's recommendations, and the Agency has corrective action plans in place for open recommendations.

### Program Management

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IFMP program authority resides in the Office of the Administrator, with Program Executive Officer Patrick Ciganer. IFMP program management resides within the Office of the Chief Financial Officer, with Program Director Bobby German. The Agency Program Management Council (PMC) has governing responsibility.

This program is in full compliance with NPG 7120.

## Supporting Data: Integrated Financial Management Program

### Technical Commitment

The initial baseline for IFMP technical commitment was made in February 2002. The baseline was updated in the FY 2005 President's Budget.

| Technical Specifications  | FY 2005 President's Budget  | Performance Measures   |
|---|---|--|
| 1. Provide timely, consistent, and reliable information for management decisions. | 1. Provide consistent, timely, and reliable financial data to Agency, Directorate, Center, Program, Project and functional managers to support decision making;<br>2. Provide on-line access to program and project data to the Agency Directorates and Centers;<br>3. Implement standardized, reengineered processes across functions and systems throughout the Agency. | *Number of Days between periodic closings and availability of financial data to internal customers.<br>*Percent of users having on-line, real time access to financial data necessary to function. |
| 2. Improve NASA's accountability and enable full cost management.                 | 1. Provide financial data for the purpose of determining the cost of providing specific Agency programs and projects;<br>2. Improve financial data consistency.   | *Number of Days between periodic closings and availability of financial data to internal customers.<br>*Percent of users having on-line, real time access to financial data necessary to function. |
| 3. Achieve efficiencies and operate effectively.                                  | 1. Streamline and standardize financial business processes across NASA to operate more effectively;<br>2. Provide tools to utilize admin and tech work force more effectively;<br>3. Provide an automated audit trail for financial data.   | *Number of applications or systems required to conduct process; for Core Financial the number of legacy systems shutdown with processes transitioned to SAP R/3.                                   |
| 4. Exchange information with customers and stakeholders.                          | 1. Provide consistent, timely, and reliable financial data to NASA's external customers;<br>2. Improve exchange of financial data among internal customers.   | *Number of applications or systems required to conduct process; for Core Financial the number of legacy systems shutdown with processes transitioned to SAP R/3.                                   |
| 5. Attract and retain a world-class workforce.                                    | 1. Provide tools to users that enable them to do their jobs more effectively;<br>2. Provide increased opportunities for sharing of data, practices and teaming across Centers.  | *Percent of users having on-line, real time access to financial data necessary to function.  |

\*IFMP benefits a broad range of NASA processes and programs and is principally aligned with the Implementing Strategy-1: achieve management and institutional excellence comparable to NASA's technical excellence, as defined in the NASA 2003 Strategic Plan. Each module project defines its functional drivers, which demonstrate how the project supports accomplishment of the Agency business drivers or technical specifications.

### Acquisition Strategy and Performing Organizations

Multiple contracts are being utilized to support IFMP, all of which are using GSA Schedule contract vehicles. These contracts support IFMP as a whole, as well as the specific module projects across the various Centers.

**Changes since FY 2005 President's Budget:** Implementation contractor and Program Management contractor selected. Also, selected software and services provider for Contract Management.

### Agreements

**Internal:** The program relies on support from each of the ten NASA Centers. Agreements and Commitments are signed with each Center responsible official prior to beginning implementation work at the Center.

**Changes since FY 2005 President's Budget: External:** Implemented agreement with Department of Interior for interface and support for ePayroll.

## Supporting Data: Integrated Financial Management Program

### Independent Reviews

| Review Types              | Performer     | Last Review Date | Next Review Date | Purpose  |
|---------------------------|---------------|------------------|------------------|--|
| Independent Annual Review | IPAO          | 19-Nov-02        | March 2005       | To validate performance of program and project commitments.  |
| Annual Financial Audit    | Ernst & Young | November 2004    | November 2005    | Audit NASA's annual Financial Statements, IT configuration and controls, and Federal Financial Management Improvement Act system compliance. |

### Budget/Life Cycle Cost (Implementation)

| Budget Authority (\$ millions)  | Prior        | FY04         | FY05         | FY06        | FY07        | FY08        | FY09        | FY10        | Total        | Comments  |
|---|--------------|--------------|--------------|-------------|-------------|-------------|-------------|-------------|--------------|---|
| FY 2006 President's Budget  | <u>236.6</u> | <u>139.8</u> | <u>74.3</u>  | <u>76.9</u> | <u>62.5</u> | <u>72.5</u> | <u>41.9</u> | <u>41.9</u> | <u>746.4</u> |   |
| Changes since FY 05 PBS   | <u>0.0</u>   | <u>22.9</u>  | <u>-41.5</u> | <u>-7.8</u> | <u>62.5</u> | <u>72.5</u> | <u>41.9</u> | <u>41.9</u> | <u>192.4</u> | Reason for Change:<br>G&A increase in FY04.<br>Reductions in FY05 & FY06 due to revised program schedule.<br>Increases starting in FY07 have equivalent offsets in sustaining costs under the NSSC budget, and do not represent additional costs to the Agency. |
| FY 2005 President's Budget  | <u>236.6</u> | <u>116.9</u> | <u>115.8</u> | <u>84.7</u> | <u>0.0</u>  | <u>0.0</u>  | <u>0.0</u>  | <u>0.0</u>  | <u>554.1</u> |   |
| Numbers may not add due to rounding                                   |              |              |              |             |             |             |             |             |              |   |
| Indicates changes since the previous year's President's Budget Submit |              |              |              |             |             |             |             |             |              |   |

## National Institute of Aerospace (NIA)

The National Institute of Aerospace (NIA) is a research and education institute initiated by NASA Langley Research Center (LaRC) to ensure a national capability to support NASA's Mission by expanding collaboration with academia and leveraging expertise inside and outside NASA. A nationwide competitive procurement process resulted in the selection of a consortium that created the non-governmental, non-profit NIA. The consortium includes the American Institute of Aeronautics and Astronautics Foundation, the Georgia Institute of Technology, the North Carolina Agricultural and Technical State University, the North Carolina State University, the University of Maryland, the University of Virginia, the Virginia Polytechnic Institute and State University, and the Hampton University as full members, and the Old Dominion University and the College of William and Mary as affiliate members. The NIA has been operational since January 3, 2003 and is, currently staffed with 36 research scientists, 12 faculty members, 30 fulltime graduate students and 22 administrative staff.

The NIA is a strategic partner conducting leading edge research working in collaboration with LaRC. The technical scope of the NIA is the research and development of aerospace vehicle technologies, atmospheric sciences, and the commercialization of intellectual property created by the NIA. In synergy with the research programs at LaRC, the NIA also has a science and engineering graduate education capability, offering 110 graduate engineering courses and seven graduate degrees, provided by its university partners.

One of the innovative aspects of the NIA is the use of information technology to create both a virtual collaborative research environment and a distance-learning educational capability leveraging the unique facilities and laboratories of LaRC and the partners. The NIA has also established a permanent location, housed in commercial rental office space, in close proximity to LaRC to enhance collaboration with LaRC research personnel and to facilitate access to the extensive world-class experimental facilities located at LaRC.

NASA will provide \$5 million per year for five years to sponsor a "core" program. The "core" program includes support to establish the initial research and education infrastructure of the NIA and to fund the Distinguished Professor program. The Distinguished Professor program is a resident scholar program intended to attract gifted researchers to the NIA. After the first five years, the NIA will develop a broader customer base and become self-sufficient, receiving no "core" funding from NASA. The only NASA funds it will receive will be from those specific programs and projects that require the NIA's services. Anticipated funding by NASA to the NIA and University cost-sharing is given below.

| Budget Authority (\$ in millions) | FY 2004<br>Actuals | FY 2005<br>Estimates | FY 2006<br>Budget |
|-----------------------------------|--------------------|----------------------|-------------------|
| NASA Funding*                     | **20.7             | 21.0                 | **** TBD          |
| University Cost-Sharing           | ***1.2             | 1.2                  | 1.2               |
| Total Program Funding             | 21.9               | 22.2                 | **** TBD          |

\* FY 2004 is actual funding; FY 2005 is an estimate and a majority of the actual funding will be determined based on program requirements.

\*\* Includes \$5M Congressional Interest Items

\*\*\* FY 2004 University Cost-Sharing is an estimate; the actual is unavailable from the NIA at the time of this submission.

\*\*\*\* FY 2006 Estimates are not completed at this time.

**Full Cost Budgeting**

For the third consecutive year, NASA has formulated its budget in “Full Cost” advancing the methods first utilized two years ago. NASA has operated in a total full cost environment since its implementation on October 1, 2003. Since then, managers have been managing programs in terms of their total costs.

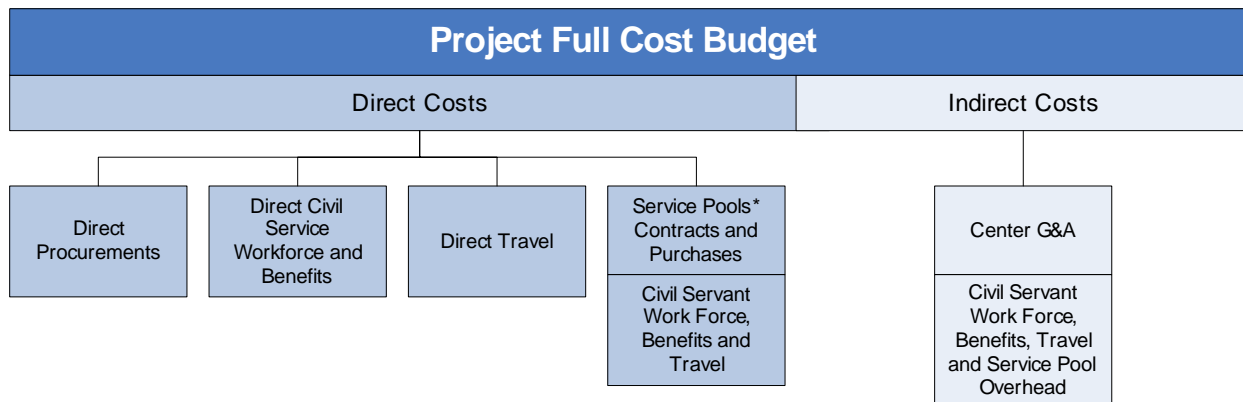
“Full cost” means that each program’s budget estimate includes all of the program’s direct and indirect costs, including all civil service salaries and infrastructure costs. Full cost budgeting directly links each program with all the resources it benefits from or consumes. This linkage is designed to provide accurate estimates and actual cost information, enabling managers to assess resources in terms of their financial cost and value to the program. Full cost budgeting also allows managers to better hold accountable those managing the resources.

Implementing full cost has been crucial to NASA’s success to integrate budget and performance as called for in the President’s Management Agenda (PMA). NASA was the first agency to receive the coveted “green” rating in this area. In response to NASA implementing the Vision for Space Exploration, the Agency has recently adapted a new budget data structure that will better facilitate full cost practices. First, budgetary reporting elements are organized according to a hierarchy: (from highest to lowest) Mission Directorate, Theme, Program and Project. Secondly, Programs and Projects are clearly distinguished from each other and managed accordingly. Projects roll up into Programs; Programs roll up into Themes; and Themes into Mission Directorates. Moreover, the Projects and Programs are scrutinized for compliance with the NASA Procedural Requirement 7120.5C “NASA Program and Project Management Processes and Requirements” document.

**Full Cost: Cost Elements and Classifications**

In full cost, each Project’s budget includes direct costs and indirect costs. Direct costs consist of those costs that can be obviously and cleanly linked to a Project—these are the costs that are “directly” controlled by a Project Manager. Indirect costs are those costs that cannot be clearly or expeditiously linked to a Project; they are instead linked through an allocation. Indirect costs include overhead for internal service pools and General and Administrative (G&A) costs incurred by NASA Centers. The full cost of a project is the sum of these costs. Figure 1 depicts in detail the cost components for each NASA full cost project.

Figure 1: Components of NASA’s Full Cost Budget



\* Costs of services provided to projects based on use/consumption

Descriptions of each cost element:

**Direct Costs**

**Direct Procurements:** The procurements that are directly controlled and acquired by the Project Manager. These costs are linked to a project at the time the costs are incurred. They include purchased goods and services, contracted support, and materials.

**Direct Civil Service Workforce and Benefits:** The costs associated with the Civil Service employees that charge their time to the Project. This includes their base pay as well as fringe benefits. These costs are incurred on a two-week cycle and linked to the Project at that time.

**Direct Travel:** The costs associated with personnel traveling for activities in support of the Project. These costs are linked to the project at the time the costs are incurred.

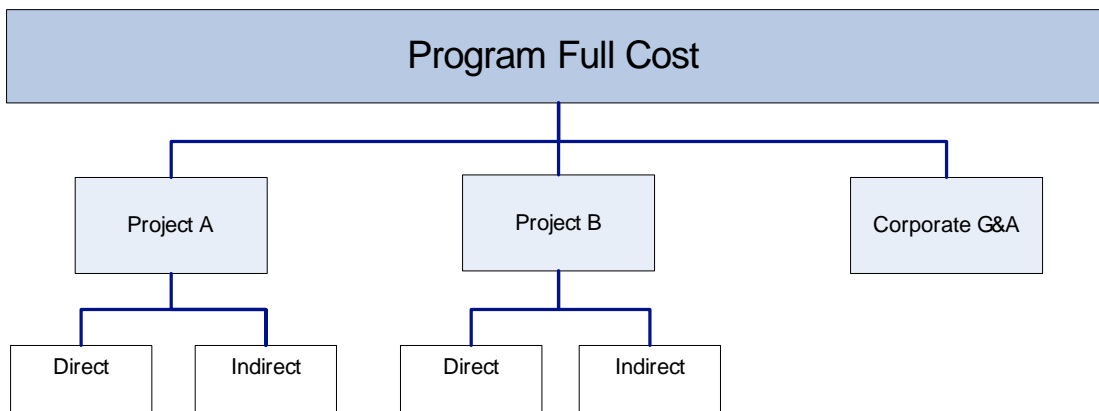
**Service Pools:** The costs of services consumed by the Project, in which the level of service is directly controlled by the Project Manager. These costs are linked back to the Project (usually on a monthly basis) in a fair, equitable manner based on pre-determined metrics, identifying the degree to which Projects benefit from the pool's services. Service pool costs include the salaries and benefits of civil servants working for the pool, as well as their travel. There are six standard service pools established for use by NASA Centers: Facilities and Related Services; Information Technology; Science and Engineering; Fabrication; Test Services; and Wind Tunnel Services.

**Indirect Costs**

**Center G&A Costs:** The costs associated with Center services such as legal, financial, medical, security, environmental, media, logistics, public affairs, human resources, administration, financial, and procurement, as well as any Center investments. These are Center costs that cannot be allocated to specific projects based on consumption. These costs are linked to each Project based on the amount of civil servants and on-site contractors working directly to support the Project. Center G&A costs include the salaries and benefits of Center civil servants in G&A functions, as well as their travel.

**Corporate G&A Costs:** The costs associated with NASA Headquarters and Agency-wide activities (including costs of Corporate G&A functions performed at NASA Centers on behalf of the Agency). Corporate functions include the NASA Administrator's office, Mission Directorate management, Headquarters operations, and the Mission Support Offices that govern Agency-wide matters, such as public affairs, procurement, finance, and human resources policy and practice. Corporate G&A costs are assessed to Programs based on their share of NASA's total cost (including service pool costs and Center G&A). Figure 2 illustrates the Program's Full Cost Budget elements.

Figure 2: Program's Full Cost Budget Elements















**President's Management Agenda**

NASA has made significant progress in improving the quality of our management by implementing the President's Management Agenda (PMA). This is an effort to improve the way that government manages in five key areas across all federal agencies: Human Capital, Financial Management, E-Government, Competitive Sourcing, and Budget and Performance Integration. NASA, like several other agencies, is also working toward improvement in a new PMA initiative: Federal Real Property Management. The President's Management Agenda provides the central focus for all management reform efforts across the Agency, including our Freedom to Manage initiatives. NASA has established a highly integrated, disciplined process for "getting to green," with weekly status reports to the Administrator by each of our PMA area champions.

NASA is a leading agency in the implementation of the PMA. This is evidenced by the fact that NASA is one of the few federal agencies to have achieved at least three "green" status ratings, in the PMA areas of Human Capital, E-Government and Budget and Performance Integration. In addition, NASA was recently honored in December 2004 with the receipt of a President's Quality Award (PQA) in Competitive Sourcing. This is the second PQA NASA has received. Previously, NASA received an honorable mention for Budget and Performance Integration efforts in FY 2003 – the only such award for Budget and Performance Integration.

NASA's progress in strengthening our management foundation and agency credibility in PMA has positioned the agency to effectively implement *The President's Vision for U.S. Space Exploration*, unveiled in January 2004.

NASA's President's Management Agenda Scorecard (December 31, 2004)

|          | Human Capital   | Competitive Sourcing  | Financial Performance   | E-Government  | Budget and Performance Integration  | Federal Real Property Management  |
|----------|---|---|---|---|---|---|
| Status*  |  |  |  |  |  |  |
| Progress |  |  |  |  |  |  |

***Human Capital***

NASA implemented a human capital plan, established an accountability system to track the associated results, and demonstrated the ability to make distinctions in employee performance using a comprehensive awards system. Further, NASA received Office of Personnel Management provisional certification for its Senior Executive Service and SL/ST performance appraisal system.

***Competitive Sourcing***

NASA has a competitive sourcing plan and has announced two standard competitions involving more than 230 positions. Additionally, an integral part of NASA's competitive sourcing plan are science competitions in which NASA scientists compete against those in academia, industry

## President's Management Agenda Update

and other government agencies for research opportunities. It is anticipated that more than 400 FTE will annually be exposed to competition through this process.

### ***Financial Performance***

NASA continues to face significant challenges in improving the quality of its financial reporting; however, the Agency has established an aggressive action plan and timetable to correct deficiencies. In 2003, NASA implemented the Core Financial Module of the Integrated Financial Management Program (IFMP) to standardize financial data and processes across Headquarters and the 10 NASA Centers. It replaced 140 disparate legacy financial systems. Data reconciliation issues due to the conversion from the old to the new systems, however, presented challenges in preparing NASA's FY 2003 and FY 2004 financial statements.

### ***E-Government***

NASA has an information technology (IT) architecture in place to guide Agency investments and strengthen IT security. All NASA IT systems are now operating within 10 percent of planned budget and schedule. NASA is committed to implementing government-wide E-gov solutions, such as the E-payroll system, that will improve the efficiency of government operations.

### ***Budget & Performance Integration***

NASA used performance information and full-cost considerations to develop the FY 2004, FY 2005 and FY 2006 budget requests and to inform the Agency's management decisions. NASA is the first government agency to have achieved green for this initiative.

### ***Federal Real Property Management***

NASA is an active participant on the Federal Real Property Council, which helps inform and develop government-wide best practices. The Agency is currently developing a comprehensive asset management plan to guide planning, acquisition, operation, and disposal of real property.



## FY 2005 Performance Plan Update

In 2004, NASA transformed its organization in order to better achieve *The Vision for Space Exploration*. As a result of this Vision for the Agency, NASA has identified 18 new Strategic Objectives that define what the Agency has been asked to accomplish. These Objectives replace the existing Objectives from the 2003 Strategic Plan, and provide the first step in the development of the new NASA strategic plan for 2006. This FY 2005 Performance Plan Update re-maps the original FY 2005 commitment for annual performance goals into the new Strategic Objectives. With only a few exceptions, this update reflects the original plan as committed in the FY 2005 Budget request. The exceptions are identified in the list of goals that have been deleted due to termination of projects not required to support the new exploration activities.

### **NASA Objective 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.**

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

5MEP5 Successfully complete the Mission Concept Review and PMSR for the 2009 Mars Telesat Orbiter (NOTE: this APG supports all MEP research focus areas).

5MEP7 Successfully demonstrate progress in characterizing the present climate of Mars and determine how it has evolved over time. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.2: Understand the history and behavior of water and other volatiles on Mars.**

5MEP1 Successfully complete Assembly, Test, and Launch Operations (ATLO) for the Mars Reconnaissance Orbiter mission.

5MEP2 Successfully launch the Mars Reconnaissance Orbiter.

5MEP8 Successfully demonstrate progress in investigating the history and behavior of water and other volatiles on Mars. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.3: Understand the chemistry, mineralogy, and chronology of Martian materials.**

5MEP9 Successfully demonstrate progress in studying the chemistry, mineralogy, and chronology of Martian materials. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.4: Determine the characteristics and dynamics of the interior of Mars.**

5MEP10 Successfully demonstrate progress in determining the characteristics and dynamics of the interior of Mars. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.5: Understand the character and extent of prebiotic chemistry on Mars.**

5MEP4 Successfully complete the Preliminary Mission System Review (PMSR) for the 2009 Mars Science Laboratory (MSL) Mission.

5MEP6 Successfully complete Preliminary Design Review (PDR) for Laser Communication Demonstration (NOTE: this APG supports all Mars Exploration research focus areas).

5MEP11 Successfully demonstrate progress in investigating the character and extent of prebiotic chemistry on Mars. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.6: Search for chemical and biological signatures of past and present life on Mars.**

5MEP3 Complete science instrument selections for the 2009 Mars Science Laboratory (MSL).

5MEP12 Successfully demonstrate progress in searching for chemical and biological signatures of past and present life on Mars. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.7: Identify and understand the hazards that the Martian environment will present to human explorers.**

5MEP13 Successfully demonstrate progress in identifying and studying the hazards that the Martian environment will present to human explorers. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 2.8: Inventory and characterize Martian resources of potential benefit to human exploration of Mars.**

5MEP14 Successfully demonstrate progress in inventorying and characterizing Martian resources of potential benefit to human exploration of Mars. Progress towards achieving outcomes will be validated by external review.

**NASA Objective 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.**

**Outcome 3.1: Understand the initial stages of planet and satellite formation.**

5SSE2 Complete integration and testing for New Horizons/Pluto.

5SSE4 Release a NASA Research Announcement (NRA) for In Space Power and Propulsion technology development activities (NOTE: this APG could potentially support multiple SSE research focus areas).

5SSE7 Successfully demonstrate progress in understanding the initial stages of planet and satellite formation. Progress towards achieving outcomes will be validated by external review.

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

5SSE8 Successfully demonstrate progress in studying the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact. Progress towards achieving outcomes will be validated by external review.

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

5SSE9 Successfully demonstrate progress in understanding why the terrestrial planets are so different from one another. Progress towards achieving outcomes will be validated by external review.

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

5SSE10 Successfully demonstrate progress in learning what our solar system can tell us about extra-solar planetary systems. Progress towards achieving outcomes will be validated by external review.

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

5SSE3 Select the next New Frontiers mission (NOTE: this APG could potentially support multiple SSE research focus areas).

5SSE11 Successfully demonstrate progress in determining the nature, history, and distribution of volatile and organic compounds in the solar system. Progress towards achieving outcomes will be validated by external review.

**Outcome 3.6: Identify the habitable zones in the solar system.**

5SSE12 Successfully demonstrate progress in identifying the habitable zones in the solar system. Progress towards achieving outcomes will be validated by external review.

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

5SSE13 Successfully demonstrate progress in identifying the sources of simple chemicals that contribute to prebiotic evolution and the emergence of life. Progress towards achieving outcomes will be validated by external review.

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

5SSE14 Successfully demonstrate progress in studying Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere. Progress towards achieving outcomes will be validated by external review.

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

5SSE5 Successfully demonstrate progress in determining the inventory and dynamics of bodies that may pose an impact hazard to Earth. Progress towards achieving outcomes will be validated by external review.

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

5SSE1 Successfully launch Deep Impact.

5SSE6 Successfully demonstrate progress in determining the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth. Progress towards achieving outcomes will be validated by external review.

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### **NASA Objective 4: Conduct advanced telescope searches for Earth-like planets and habitable environments around the stars.**

#### **Outcome 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.**

5ASO4 Demonstrate James Webb Space Telescope (JWST) primary mirror technology readiness by testing a prototype in a flight-like environment.

5ASO5 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 towards achieving outcomes will be validated by external review.

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

5ASO6 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 towards achieving outcomes will be validated by external review.

#### **Outcome 4.3: Learn how gas and dust become stars and planets.**

5ASO7 Successfully demonstrate progress in learning how gas and dust become stars and planets. Progress towards achieving outcomes will be validated by external review.

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

5ASO3 Demonstrate system-level instrument pointing precision consistent with SIM's flight system basic performance requirements, as specified in program plan.

5ASO8 Successfully demonstrate progress in observing planetary systems around other stars and comparing their architectures and evolution with our own. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 4.5: Characterize the giant planets orbiting other stars.**

5ASO9 Successfully demonstrate progress in characterizing the giant planets orbiting other stars. Progress towards achieving outcomes will be validated by external review.

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

5ASO2 Successfully complete the Kepler mission Preliminary Design Review (PDR).

5ASO10 Successfully demonstrate progress in finding out how common Earth-like planets are and seeing if any might be habitable. Progress towards achieving outcomes will be validated by external review.

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

5ASO1 Deliver the SOFIA Airborne Observatory to Ames Research Center for final testing.

5ASO11 Successfully demonstrate progress in tracing the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life. Progress towards achieving outcomes will be validated by external review.

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

5ASO12 Successfully demonstrate progress in developing the tools and techniques to search for life on planets beyond our solar system. Progress towards achieving outcomes will be validated by external review.

### **NASA Objective 5: Explore the universe to understand its origin, structure, evolution, and destiny.**

#### **Outcome 5.1: Search for gravitational waves from the earliest moments of the Big Bang.**

5SEU4 Successfully demonstrate progress in search for gravitational waves from the earliest moments of the Big Bang. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 5.2: Determine the size, shape, and matter-energy content of the universe.**

5SEU5 Successfully demonstrate progress in determining the size, shape, and matter-energy content of the universe. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 5.3: Measure the cosmic evolution of dark energy.**

5SEU6 Successfully demonstrate progress in measuring the cosmic evolution of the dark energy, which controls the destiny of the universe. Progress towards achieving outcomes will be validated by external review.

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### **Outcome 5.4: Determine how black holes are formed, where they are, and how they evolve.**

5SEU7 Successfully demonstrate progress in determining how black holes are formed, where they are, and how they evolve. Progress towards achieving outcomes will be validated by external review.

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

5SEU8 Successfully demonstrate progress in testing Einstein's theory of gravity and mapping space-time near event horizons of black holes. Progress towards achieving outcomes will be validated by external review.

### **Outcome 5.6: Observe stars and other material plunging into black holes.**

5SEU9 Successfully demonstrate progress in observing stars and other material plunging into black holes. Progress towards achieving outcomes will be validated by external review.

### **Outcome 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.**

5SEU10 Successfully demonstrate progress in determining how, where, and when the chemical elements were made, and tracing the flows of energy and magnetic fields that exchange them between stars, dust, and gas. Progress towards achieving outcomes will be validated by external review.

### **Outcome 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.**

5SEU1 Complete the integration and testing of the Gamma-ray Large Area Space Telescope (GLAST) spacecraft bus.

5SEU11 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 towards achieving outcomes will be validated by external review.

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

5SEU12 Successfully demonstrate progress in discovering how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies. Progress towards achieving outcomes will be validated by external review.

## **NASA Objective 6: Return the Space Shuttle to flight and focus its use on completion of the International Space Station, complete assembly of the ISS, and retire the Space Shuttle in 2010, following completion of its role in ISS assembly. Conduct ISS activities consistent with U.S. obligations to ISS partners.**

### **Outcome 6.1: Assure public, flight crew, and workforce safety for all Space Shuttle operations, and safely meet the manifest and flight rate commitment through completion of Space Station assembly.**

5SSP1 Achieve zero Type-A (damage to property at least \$1M or death) or Type-B (damage to property at least \$250K or permanent disability or hospitalization of three or more persons) mishaps in FY 2005.

5SSP2 Achieve an average of eight or fewer flight anomalies per Space Shuttle mission in FY 2005.

5SSP3 Achieve 100 percent on-orbit mission success for all Shuttle missions launched in FY 2005. For this metric, mission success criteria are those provided to the prime contractor (SFOC) for purposes of determining successful accomplishment of the performance incentive fees in the contract.

### **Outcome 6.2: Provide safe, well-managed and 95 percent reliable space communications, rocket propulsion testing, and launch services to meet Agency requirements.**

5SFS8 Establish the Agency-wide baseline space communications architecture, including a framework for possible deep space and near Earth laser communications services.

5SFS15 Maintain NASA success rate at or above a running average of 95% for missions on the FY 2005 Expendable Launch Vehicle (ELV) manifest.

5SFS16 Achieve at least 95% of planned data delivery for the International Space Station, each Space Shuttle mission, and low-Earth orbiting missions in FY 2005.

5SFS19 Define and provide space transportation requirements for future human and robotic exploration and development of space to all NASA and other government agency programs pursuing improvements in space transportation.

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**NASA Objective 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.**

**Outcome 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.**

- 5TS1 Conduct a detailed review of previous vehicle programs to capture lessons-learned and appropriate technology maturation; incorporate results into the human exploration vehicle requirements definition process.
- 5TS2 Develop and obtain approval for human exploration vehicle Level 1 and Level 2 Requirements and the resulting Program Plan.
- 5TS3 Complete preliminary conceptual design(s) for the human exploration vehicle, in conjunction with definition of an integrated exploration systems architecture.
- 5TS4 Develop launch vehicle Level 1 Requirements for human-robotic exploration within an integrated architecture, and define corresponding programs to assure the timely availability of needed capabilities, including automated rendezvous, proximity operations and docking, modular structure assembly, in space refueling, and launch vehicle modifications and developments.
- 5TS5 Conduct a preliminary conceptual design study for a human-robotic Mars exploration vehicle, in conjunction with definition of an integrated exploration systems architecture.

**NASA Objective 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.**

**Outcome 8.1: By 2010 complete assembly of the ISS, including U.S. components that support U.S. space exploration goals and those provided by foreign partners.**

- 5ISS5 Obtain agreement among the International Partners on the final ISS configuration.

**Outcome 8.2: Annually provide 90 percent of the optimal on-orbit resources available to support research, including power, data, crew time, logistics, and accommodations.**

- 5ISS1 In concert with the ISS International Partners, extend a continuous two-person (or greater) crew presence on the ISS through the end of FY 2004.
- 5ISS2 Achieve zero Type-A (damage to property at least \$1M or death) or Type-B (damage to property at least \$250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY 2005.
- 5ISS3 Based on the Space Shuttle return-to-flight plan, establish a revised baseline for ISS assembly (through International Core Complete) and research support.
- 5ISS4 Provide at least 80% of up-mass, volume and crew-time for science as planned at the beginning of FY 2005.
- 5ISS6 Continuously sustain a crew to conduct research aboard the ISS.

**Outcome 8.4: By 2006, each Research Partnership Center will establish at least one new partnership with a major NASA R&D program to conduct dual-use research that benefits NASA, industry, or academia.**

- 5RPFS4 Promote availability of RPC-built spaceflight hardware throughout NASA utilizing the new database.
- 5RPFS5 Implement hardware sharing system.
- 5RPFS6 Identify and develop a working relationship with at least one new non-SPD user of RPC-built spaceflight hardware.

**Outcome 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.**

- 5BSR7 Increase the use of space flight analogs on the ground to better define hypotheses for flight experiments.
- 5BSR8 Publish final results of Bioastronautics experiments conducted during ISS increment 8 and preliminary results from Increments 9 and 10.
- 5BSR9 Maintain productive peer-reviewed research program in Biomedical Research and Countermeasures including a National Space Biomedical Research Institute that will perform team-based focused countermeasure-development research.
- 5BSR10 Under the Human Research Initiative (HRI) increase the number of investigations addressing biomedical issues associated with human space exploration.

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- 5BSR11 Conduct scientific workshops to fully engage the scientific community in defining research strategies for addressing and solving NASA's biomedical risks.
- 5SFS20 Certify the medical fitness of all crew members before launch.

### **Outcome 8.6: By 2008, reduce the uncertainties in estimating radiation risks by one-half.**

- 5BSR12 Expand the space radiation research science community to involve cutting edge researchers in related disciplines by soliciting, selecting, and funding high quality research.
- 5BSR13 Use 1000 hours/yr of beam time at the National Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory (BNL) to measure survival, genetic mutation (mutagenesis) and chromosome aberrations in cells and tissues to improve understanding of the biological effects of the space radiation environment.
- 5BSR14 Integrate research data collected over the past two years at NSRL, with existing database to develop more accurate predictions resulting in improved biological strategies for radiation risk reduction.

### **Outcome 8.7: By 2010, identify and test technologies to reduce total mass requirements for life support by two thirds using current ISS mass requirement baseline.**

- 5BSR17 Demonstrate, through vigorous research and technology development, a 55% reduction in the projected mass of a life support flight system compared to the system base-lined for ISS.

### **Outcome 8.8: By 2008, develop a predictive model and prototype systems to double improvements in radiation shielding efficiency.**

- 5PSR9 Continue accumulating data on radiation effects on materials properties and initiate the assessment of the performance of multifunctional materials.

## **NASA Objective 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.**

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

- 5HRT1 Establish an integrated, top-down strategy-to-task technology R&D planning process to facilitate the development of human-robotic exploration systems requirements.
- 5HRT2 Execute two systems-focused Quality Function Deployment exercises through an Operational Advisory Group (including both technologists and operators) to better define systems attributes necessary to accomplish human-robotic exploration operational objectives.
- 5HRT3 Execute selected R&D-focused Quality Function Deployment exercises through an external/internal Technology Transition Team to review candidate human-robotic exploration systems technologies, and provide detailed updates to human-robotic technology road maps.
- 5HRT4 Test and validate preferred engineering modeling and simulation computational approaches through which viable candidate architectures, systems designs and technologies may be identified and characterized. Select one or more approaches for ongoing use in systems/technology road mapping and planning.
- 5LE1 Identify and define preferred human-robotic exploration systems concepts and architectural approaches for validation through lunar missions.
- 5LE2 Identify candidate architectures and systems approaches that can be developed and demonstrated through lunar missions to enable a safe, affordable and effective campaign of human-robotic Mars exploration.
- 5LE6 Identify preferred approaches for development and demonstration during lunar missions to enable transformational space operations capabilities.
- 5LE7 Conduct reviews with international and U.S. government partners, to determine common capability requirements and opportunities for collaboration.

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

- 5HRT5 Identify and analyze viable candidates and identify the preferred approach to sustained, integrated human-robotic solar system exploration involving lunar/planetary surfaces and small bodies, and supporting operations. Validate a focused technology R&D portfolio that addresses the needs of these approaches and identifies existing gaps in technological capabilities.

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- 5HRT6 Establish and obtain approval for detailed R&D requirements, roadmaps and program planning in key focused technology development areas, including self-sufficient space systems; space utilities and power; habitation and bioastronautics; space assembly, maintenance and servicing; space transportation; robotic networks; and information technology and communications.
- 5LE3 Establish a baseline plan and Level 1 requirements to utilize the robotic lunar orbiter(s) and robotic lunar surface mission(s) to collect key engineering data and validate environmental characteristics and effects that might affect later robotics, astronauts and supporting systems.
- 5LE4 Identify candidate scientific research and discovery opportunities that could be pursued effectively during robotic lunar missions.
- 5LE5 Establish a viable investment portfolio for development of human support systems, including human/machine extravehicular activity (EVA) systems, locally autonomous medical systems and needed improvements in human performance and productivity beyond low Earth orbit (LEO).

### **Outcome 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.**

- 5HRT7 Develop Level 1/ Level 2 requirements for nuclear power and propulsion systems in support of selected human and robotic exploration architectures and mission concepts.
- 5HRT8 Complete a validated road map for nuclear power and propulsion R&D, and related vehicle systems technology maturation.
- 5HRT9 Formulate a demonstration mission plan for Jupiter Icy Moons Orbiter that will test and validate nuclear power and propulsion systems for future human-robotic exploration missions.

### **Outcome 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.**

- 5HRT15 Complete an Advanced Space Technology Program technology roadmap that interfaces appropriately with the technology planning of NASA's Mission Directorates.
- 5HRT16 Deliver at least one new critical technology in each key area (including: in-space computing, space communications and networking, sensor technology, modular systems, and engineering risk analysis) to NASA's Mission Directorates, for possible test and demonstration.
- 5HRT17 Prepare and announce the Centennial Challenge Cycle 2 major award purses, including competition rules, regulations, and judgment criteria.

### **Outcome 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.**

- 5HRT12 Establish three partnerships with U.S. industry and the investment community using the Enterprise Engine concept.
- 5HRT13 Develop 12 industry partnerships, including the three established using the Enterprise Engine, that will add value to NASA Mission Directorates.

### **Outcome 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 Phase II firms to further develop or produce their technology for industry or government agencies.**

- 5HRT14 Achieve through NASBO, the award of Phase III contracts or venture capital funds to no less than two SBIR firms to further develop or produce their technology through industry or government agencies.

### **Outcome 11.10: By 2005, demonstrate two prototype systems that prove the feasibility of resilient systems to mitigate risks in key NASA mission domains. Feasibility will be demonstrated by reconfigurability of avionics, sensors, and system performance parameters.**

- 5HRT10 Develop prototype design and organizational risk analysis tools to do risk identifications, assessments, mitigation strategies, and key trade-off capabilities not only between risks, but between risks and other mission design criteria.
- 5HRT11 Develop a robust software tool for accident investigation that can help identify the causes of spacecraft, airplane, and/or other mission hardware accidents.

### **NASA Objective 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.**

#### **Outcome 12.1: By 2005, research, develop, and transfer technologies that would enable the reduction of the aviation fatal accident rate by 50 percent from the FY 1991-1996 average.**

- 5AT1 Evaluate and flight validate selected next generation cockpit weather information, communications, airborne weather reporting, turbulence prediction and warning technologies, Synthetic Vision System and Runway Incursion Prevention System display concepts. The flight demonstration will illustrate the increased safety of integrating selected concepts in support of fleet implementation decisions. (AvSSP)
- 5AT2 Demonstrate through applications and simulations safety-improvement systems that will illustrate the increased safety of integrating selected concepts in support of fleet implementation decisions. (AvSSP)

#### **Outcome 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).**

- 5AT3 Create and establish a prototype data collection system for confidential, non-punitive reporting on aviation security by functional personnel in the aviation system.
- 5AT16 Develop a preliminary joint research plan with the Transportation Security Administration (TSA). (AvSSP)

#### **Outcome 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.**

- 5AT4 Using laboratory data and systems analysis, complete selection of the technologies that show the highest potential for reducing commercial air transportation noise by at least 50%. (Vehicle Systems)

#### **Outcome 12.4: By 2010, flight demonstrate an aircraft that produces no CO<sub>2</sub> or NO<sub>x</sub> to reduce smog and lower atmospheric ozone.**

- 5AT5 Demonstrate 70% reduction NO<sub>x</sub> emissions in full-annular rig tests of candidate combustor configurations for large subsonic vehicle applications. (Vehicle Systems)
- 5AT6 Based on laboratory data and systems analysis, select unconventional engine or power systems for technology development that show highest potential for reducing CO<sub>2</sub> emissions and/or enabling advanced air vehicles for new scientific missions. (Vehicle Systems)
- 5AT7 Complete laboratory aerodynamic assessment of low-drag slotted wing concept. (Vehicle Systems)
- 5AT27 Demonstrate through sector testing a full scale CMC turbine vane that will reduce cooling flow requirements and thus fuel burn in future turbine engine system designs. (Vehicle Systems)

#### **Outcome 12.5: By 2005, develop, demonstrate, and transfer key enabling capabilities for a small aircraft transportation system.**

- 5AT10 Complete experimental validation of airborne systems with concept vehicle development.

#### **Outcome 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).**

- 5AT8 Complete development of WakeVAS concept of operations and downselect WakeVAS architecture.
- 5AT9 Complete human-in-the-loop concept and technology evaluation of shared separation. (Airspace Systems)
- 5AT11 Complete analysis of capacity-increasing operational concepts and technology roadmaps with VAST models, simulations, and Common Scenario Set. (Airspace Systems)
- 5AT12 Develop display guidelines that exploit new understanding of perceptual systems and cognitive and physiological determinants of human performance. (Airspace Systems)
- 5AT13 Establish the fluid dynamics mechanism for alleviating wake through experimental and computational fluid mechanics studies. (Airspace Systems)
- 5AT14 Complete System-Wide Evaluation and Planning Tool initial simulation and field demonstration. (Airspace Systems)
- 5AT15 Complete communications, navigation, and surveillance requirements analysis. (Airspace Systems)
- 5AT17 Complete NASA / Industry / DoD studies of heavy-lift Vertical Take Off and Landing (VTOL) configurations to provide strategic input for future decisions on commercial / military Runway Independent Vehicles. (Vehicle Systems)



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5AT22 Using laboratory data and systems analysis, complete selection of the technologies that show the highest potential for reducing takeoff/landing field length while maintaining cruise Mach, low speed controllability and low noise. (Vehicle Systems)

### **Outcome 12.9: Develop technologies that would enable solar powered vehicles to serve as "sub-orbital satellites" for science missions.**

5AT20 Complete flight demonstration of a second generation damage adaptive flight control system. (Vehicle Systems)

5AT21 Define requirements for a robust, fault-tolerant avionics architecture that supports fully autonomous vehicle concepts. (Vehicle Systems)

5AT24 Complete laboratory aerodynamic assessment of low-drag slotted wing concept. (Vehicle Systems)

5AT25 Based on laboratory data and systems analysis, select unconventional engine or power systems for technology development that show highest potential for reducing CO2 emissions and/or enabling advanced air vehicles for new scientific missions. (Vehicle Systems)

5AT26 Complete initial flight series for validation of improved HALE ROA aero-structural modeling tools used to reduce risk and increase mission success. (Vehicle Systems)

### **Outcome 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.**

5AT23 Demonstrate integrated technologies and policies for UAV flight operations above FL400. (Vehicle Systems)

### **Outcome 12.11: Reduce the effects of sonic boom levels to permit overland supersonic flight in normal operations.**

5AT19 Complete supersonic inlet design requirements study that will identify technology gaps and priorities required for design of future efficient long range supersonic propulsion systems. (Vehicle Systems)

## **NASA Objective 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.**

### **Outcome 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.**

5ED1 Increase NASA student participation by 5% above baseline.

5ED2 Increase NASA teacher participation by 5% above baseline.

5ED3 Increase existing NASA-sponsored family involvement activities and existing and potential partners by 5% over baseline.

5ED4 25% of NASA elementary and secondary programs are aligned with state or local STEM educational objectives.

### **Outcome 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.**

5ED5 Establish a NASA-wide baseline of the diversity of NASA-supported students.

5ED6 Use existing higher education programs to assist and encourage first time faculty proposers for NASA research and development opportunities.

5ED7 Establish a baseline of institutions receiving NASA research and development grants and contracts that link their research and development to the institution's school of education.

5ED8 Establish a baseline of the number and diversity of students conducting NASA-relevant research.

### **Outcome 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.**

- 5ED9 Increase NASA underrepresented/underserved student participation by 5% over baseline.
- 5ED10 Increase NASA underrepresented/underserved teacher/faculty participation in NASA STEM-related learning environments by 5% over baseline.
- 5ED11 Increase the numbers of underserved/underrepresented researchers and minority serving institutions competing for NASA research announcements by 5% above baseline.
- 5ED12 Establish a baseline of family involvement in underrepresented/underserved NASA-sponsored student programs.

### **Outcome 13.4: Develop and deploy technology applications, products, services, and infrastructure that would enhance the educational process for formal and informal education.**

- 5ED13 Implement 1 new advanced technology application.
- 5ED14 Evaluate the 50 pilot NASA Explorer Schools, utilizing a design experiment approach.
- 5ED15 Develop a plan for establishing a technology infrastructure.

### **Outcome 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.**

- 5ED16 Implement Phase 1 of a plan to increase appreciation of the relevance and role of NASA science and technology.
- 5ED17 Develop a plan to assess and prioritize high-leverage and critical informal education programs and educational involvement activities.
- 5ED18 Develop a plan to assess current NASA professional development programs for relevance to the targeted informal learning environments.
- 5AT18 Partner with museums and other cultural organizations and institutions to engage non-traditional audiences in NASA missions.
- 5ESA11 Provide in public venues at least 50 stories on the scientific discoveries, the practical benefits, or new technologies sponsored by the Earth Science programs.
- 5ESS10 Post the most exciting imagery and explanations about Earth science on the Earth observations/Science Mission Directorate website.
- 5RPFS9 Expand outreach activities that reach minority and under-represented sectors of the public, through increased participation in conferences and community events that reflect cultural awareness and outreach. Each fiscal year, increase the previous year baseline by supporting at least one new venue that focuses on these public sectors.

## **NASA Objective 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.**

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

- 5ESA1 Crosscutting Solutions: Work within the Joint Agency Committee on Imagery Evaluation and the Commercial Remote Sensing Policy Working Group through partnerships with NIMA, USGS, NOAA, and USDA to verify/validate at least two commercial remote sensing sources/products for Earth science research, specifically with respect to land use/land cover observations for carbon cycle and water cycle research.
- 5ESA2 National Apps: Benchmark measurable enhancements to at least 2 national decision support systems using NASA results, specifically in the Disaster Management and Air Quality communities. These projects will benchmark the use of observations from 5 sensors from NASA research satellites.
- 5ESA3 Crosscutting Solutions: Expand DEVELOP (Digital Earth Virtual Environment and Learning Outreach Project) human capital development program to increase the capacity for the Earth science community at a level of 100 program graduates per year and perform significant student-led activities using NASA research results for decision support with representation in 30 states during the fiscal year.

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- 5ESA4 Crosscutting Solutions: Benchmark solutions from at least 5 projects that were selected in FY03 REASoN program to serve national applications through projects that support decision support in areas such as agriculture, public health and water quality. These projects will benchmark use of observations from at least 5 sensors from NASA research satellites.
- 5ESA5 The DEVELOP (Digital Earth Virtual Environment and Learning Outreach Project) program will advance the capacity of our future workforce with students from at least 20 states working to develop and deliver benchmark results of at least 4 rapid prototype projects using NASA Earth science research results in decision support tools for state, local and tribal government applications.
- 5ESA6 Crosscutting Solutions: Benchmark solutions associated with at least 5 decision support systems that assimilate predictions from Earth system science models (e.g. GISS, GFDL, NCEP, SpoRT, and the Earth Science laboratories).
- 5ESA7 National applications: Benchmark enhancements to at least 2 national decision support systems using NASA results, specifically in the Disaster Management, Public Health, and Air Quality communities. These projects will benchmark the use of observations from 5 sensors from NASA research satellites.
- 5ESA8 Crosscutting Solutions: Verify and validate solutions for at least 5 decision support systems in areas of national priority associated with the FY03 selected REASoN projects.
- 5ESA9 Benchmark the use of predictions from 2 NASA Earth system science models (including the GISS 1200 and NCEP weather prediction) for use in national priorities, such as support for the Climate Change Science Program (CCSP) and Climate Change Technology Program (CCTP) and the NOAA National Weather Service.
- 5ESA10 Benchmark the use of observations and predictions of Earth science research results in 2 scenarios assessment tools, such as tools used by the Environmental Protection Agency (specifically in the Community Multi-scale and Air Quality (CMAQ) Improvement Program tools) and the Department of Energy.

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

- 5ESS1 Integrate satellite, suborbital, ground based observations, coupled with laboratory studies and model calculations to assess potential for future ozone depletion in the Arctic. Characterize properties and distributions of clouds and aerosols as they relate to the extinction of solar radiation in the atmosphere. Specific output: first release of validated Aura data. Progress toward achieving outcomes will be validated by external review.
- 5ESS2 Improve predictive capabilities of regional models using satellite-derived localized temperature and moisture profiles and ensemble modeling. Progress toward achieving outcomes will be validated by external review.
- 5ESS3 Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Specific output: Produce a multi-year global inventory of fire occurrence and extent. Progress toward achieving outcomes will be validated by external review.
- 5ESS4 Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Specific Output: Release first synthesis of results from research on the effects of deforestation and agricultural land use in Amazonia. Progress toward achieving outcomes will be validated by external review.
- 5ESS5 Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Specific output: Improve knowledge of processes affecting carbon flux within the coastal zone, as well as sources and sinks of aquatic carbon, to reduce uncertainty in North American carbon models. Progress toward achieving outcomes will be validated by external review.
- 5ESS6 Enhance land surface modeling efforts, which will lead to improved estimates of soil moisture and run-off. Specific output: launch Cloudsat. Progress toward achieving outcomes will be validated by external review.
- 5ESS7 Assimilate satellite/in situ observations into variety of ocean, atmosphere, and ice models for purposes of state estimation; provide experimental predictions on variety of climatological timescales; determine plausibility of these predictions using validation strategies. Specific output: documented assessment of relative impact of different climate forcings on long-term climate change and climate sensitivities to those various forcings.
- 5ESS8 Assimilate satellite/in situ observations into variety of ocean, atmosphere, and ice models for purposes of state estimation; provide experimental predictions on variety of climatological timescales; determine plausibility of these predictions using validation strategies. Specific output: An assimilated product of ocean state on a quarter degree grid.
- 5ESS9 Advance understanding of surface change through improved geodetic reference frame, estimates of mass flux from satellite observations of Earth's gravitational and magnetic fields, and airborne and spaceborne observations of surface height and deformation. Progress toward achieving outcomes will be validated by external review.

### **NASA Objective 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.**

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

5SEC2 Successfully complete Solar Dynamics Observatory (SDO) Critical Design Review (CDR).

5SEC3 Successfully complete THEMIS Critical Design Review (CDR).

5SEC6 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 towards achieving outcomes will be validated by external review.

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

5SEC4 Complete Announcement of Opportunity (AO) Selection for Geospace Missions far ultraviolet Imager.

5SEC7 Successfully demonstrate progress in specifying and enabling prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere. Progress towards achieving outcomes will be validated by external review.

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

5SEC8 Successfully demonstrate progress in understanding the role of solar variability in driving space climate and global change in the Earth's atmosphere. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 15.4: Understand the structure and dynamics of the Sun and solar wind and the origins of magnetic variability.**

5SEC1 Complete Solar Terrestrial Relations Observatory (STEREO) instrument integration.

5SEC9 Successfully demonstrate progress in understanding the structure and dynamics of the Sun and solar wind and the origins of magnetic variability. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 15.5: Determine the evolution of the heliosphere and its interaction with the galaxy.**

5SEC10 Successfully demonstrate progress in determining the evolution of the heliosphere and its interaction with the galaxy. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 15.6: Understand the response of magnetospheres and atmospheres to external and internal drivers.**

5SEC11 Successfully demonstrate progress in understanding the response of magnetospheres and atmospheres to external and internal drivers. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 15.7: Discover how magnetic fields are created and evolve and how charged particles are accelerated.**

5SEC12 Successfully demonstrate progress in discovering how magnetic fields are created and evolve and how charged particles are accelerated. Progress towards achieving outcomes will be validated by external review.

#### **Outcome 15.8: Understand coupling across multiple scale lengths and its generality in plasma systems.**

5SEC13 Successfully demonstrate progress in understanding coupling across multiple scale lengths and its generality in plasma systems. Progress towards achieving outcomes will be validated by external review.

**NASA Objective 17: Pursue commercial opportunities for providing transportation and other services supporting International Space Station and exploration missions beyond Earth orbit. Separate to the maximum extent practical crew from cargo.**

**Outcome 17.1: By 2010, provide 80 percent of optimal ISS up-mass, down-mass, and crew availability using non-Shuttle crew and cargo services.**

5ISS7 Baseline a strategy and initiate procurement of cargo delivery service to the ISS.

**NASA Objective 18: Use U.S. commercial space capabilities and services to fulfill NASA requirements to the maximum extent practical and continue to involve, or increase the involvement of, the U.S. private sector in design and development of space systems.**

**Outcome 18.1: On an annual basis, develop an average of at least five new agreements per NASA Field Center with the Nation's industrial and other sectors for transfer out of NASA developed technology.**

5HRT18 Complete 50 technology transfer agreements with the U.S. private sector for the transfer of NASA technologies, through hardware licenses, software usage agreements, facility usage agreements or Space Act Agreements.

## Efficiency Measures

### Solar System Exploration

- 5SSE15 Complete all development projects within 110% of the cost and schedule baseline.
- 5SSE16 Deliver at least 90% of scheduled operating hours for all operations and research facilities.
- 5SSE17 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.
- 5LE8 The Robotic Lunar Exploration Program will distribute at least 80% of its allocated procurement funding to competitively awarded contracts.

### The Universe

- 5ASO13 Complete all development projects within 110% of the cost and schedule baseline.
- 5ASO14 Deliver at least 90% of scheduled operating hours for all operations and research facilities.
- 5ASO15 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

### Earth-Sun System

- 5SEC14 Complete all development projects within 110% of the cost and schedule baseline.
- 5SEC15 Deliver at least 90% of scheduled operating hours for all operations and research facilities.
- 5SEC16 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

### Constellation Systems

- 5TS6 Distribute at least 80% of allocated procurement funding to competitively awarded contracts, including continuing and new contract activities.

### Exploration Systems Research and Technology

- 5HRT15 Distribute at least 80% of allocated procurement funding to competitively awarded contracts, including continuing and new contract activities.

### Human Systems Research and Technology

- 5BSR18 Complete all development projects within 110% of the cost and schedule baseline.
- 5BSR19 Deliver at least 90% of scheduled operating hours for all operations and research facilities.
- 5BSR20 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

### Aeronautics Technology

- 5AT28 This Theme will complete 90% of the major milestones planned for FY 2005.

### Education Programs

- 5ED19 At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.

### International Space Station

- 5ISS8 Complete all development projects within 110% of the cost and schedule baseline.
- 5ISS9 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

### Space Shuttle

- 5SSP4 Complete all development projects within 110% of the cost and schedule baseline.
- 5SSP5 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

### Space and Flight Support

- 5SFS21 Complete all development projects within 110% of the cost and schedule baseline.
- 5SFS22 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

## Deleted Annual Performance Goals in FY 2005

The following goals have been deleted due to termination of projects not required to support NASA's new exploration activities.

- 5RPFS1 Implement SPD realignment plan by establishing three partnerships between SPD and other divisions of OBPR.
- 5RPFS2 Involve RPC industrial partners in at least one new project that directly benefits NASA's mission.
- 5RPFS3 Based on present manifest, begin on-orbit containerless processing of new ceramic materials using Space-DRUMS hardware installed on ISS.
  - 5PSR1 Develop a multi-agency collaboration for research at the interface between the physical and life sciences, and enhance collaborative efforts with other agencies and the private sector on biotechnology, materials research, and optical diagnostics for health research.
  - 5PSR2 Continue a productive ground and flight-based research program in Combustion, Fluid Physics, Biotechnology, and Materials science, and carry out the milestones for all ISS research projects.
  - 5PSR3 Publish the results of STS-107 investigations based on available data in microgravity combustion research, and maintain a productive ground and flight-based program in fundamental and strategic combustion and reactive flows research.
- 5RPFS7 Develop a prototype system based on one new enabling technology to improve the safety of space transportation systems.
  - 5BSR1 Solicit ground-based research on three widely studied model organisms.
  - 5BSR2 Implement a tactical plan for plant research and solicit studies appropriate to that plan on at least two model plant species.
  - 5BSR3 Solicit ground-based research on responses of cells and pathogens to space environments.
  - 5BSR4 Initiate intra- and interagency programs to study microbial ecology and evolution.
  - 5BSR5 Develop selected flight research experiments on two model organisms in coordination with research teams for identified flight opportunities.
  - 5BSR6 Align reprioritized fundamental biology flight experiments with available hardware and hardware development.
- 5PSR4 Continue flight and ground-based research in colloidal physics and soft-condensed matter, and accomplish the project milestones for the ISS research program in fluid physics.
- 5PSR5 Continue the development of the ISS fundamental physics facility for low temperature and condensed matter physics, and maintain a productive ground-based research program in condensed matter physics.
- 5PSR6 Continue the development of the ISS laser cooling and atomic facility by accomplishing the project milestones, and maintain an innovative and outstanding ground research program in atomic and gravitational physics.
- 5PSR7 Continue the development of the ISS Biotechnology Facility and maintain a productive and innovative ground and space research program in cellular biotechnology and tissue engineering.
- 5RPFS8 Through collaboration with PAO, establish and sustain a series of media briefings highlighting OBPR research.
- 5BSR15 Maintain a completed, productive, peer-reviewed ground-based research program in appropriate fundamental biology disciplines to lay the groundwork for advanced understanding of the role of gravity in biological processes associated with the human health risk of space flight.
- 5BSR16 Initiate a nanosatellite program for in-situ analytical technology for producing the fundamental biological understanding necessary for countermeasure development.
  - 5PSR8 Continue Strategic ground-based research in microgravity heat-exchange multi-phase systems and advance existing flight projects toward flight.

## FY 2006 Performance Plan

With the release of the FY 2006 Budget request, NASA has identified 18 new Strategic Objectives that define what the Agency has been asked to accomplish in support of *The Vision for Space Exploration*. This table provides a summary of all of the commitments identified by each of the 12 Themes in the preceding sections.

**NASA Objective 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.**

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

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

**NASA Objective 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.**

**Outcome 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.

**Outcome 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.

**Outcome 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).

**Outcome 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.

**Outcome 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).

**Outcome 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).

**Outcome 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.

**Outcome 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.

**NASA Objective 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.**

**Outcome 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.



## FY 2006 Performance Plan

6SSE26 Successfully return Stardust science samples to Earth.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

## **NASA Objective 4: Conduct advanced telescope searches for Earth-like planets and habitable environments around the stars.**

### **Outcome 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).

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### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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).

### **Outcome 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.

### **Outcome 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.

## **NASA Objective 5: Explore the universe to understand its origin, structure, evolution, and destiny.**

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

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### **Outcome 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.

### **Outcome 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).

### **Outcome 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.

## **NASA Objective 6: Return the Space Shuttle to flight and focus its use on completion of the International Space Station, complete assembly of the ISS, and retire the Space Shuttle in 2010, following completion of its role in ISS assembly. Conduct ISS activities consistent with U.S. obligations to ISS partners.**

### **Outcome 6.1: Assure public, flight crew, and workforce safety for all Space Shuttle operations, and safely meet the manifest and flight rate commitment through completion of Space Station assembly.**

6SSP1 Achieve zero Type A (damage to property at least \$1M or death) or Type B (damage to property at least \$250K or permanent hospitalization of three or more persons) mishaps in 2006.

### **Outcome 6.2: Provide safe, well-managed and 95 percent reliable space communications, rocket propulsion testing, and launch services to meet Agency requirements.**

6SFS1 Establish the Agency-wide baseline space communications architecture, including a framework for possible deep space and near Earth laser communications services.

6SFS2 Maintain NASA success rate at or above a running average of 95 percent for missions on the FY 2005 Expendable Launch Vehicle (ELV) manifest.

6SFS3 Achieve at least 95 percent of planned data delivery for the International Space Station, each Space Shuttle mission, and low Earth orbiting missions for FY 2005.

6SFS4 Define and provide space transportation requirements for future human and robotic exploration and development of space to all NASA and other government agency programs pursuing improvements in space transportation.

## **NASA Objective 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.**

### **Outcome 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.

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**NASA Objective 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.**

**Outcome 8.1: By 2010 complete assembly of the ISS, including U.S. components that support U.S. space exploration goals and those provided by foreign partners.**

6ISS1 Reach agreement among the International Partners on the final ISS configuration.

**Outcome 8.2: Annually provide 90 percent of the optimal on-orbit resources available to support research, including power, data, crew time, logistics, and accommodations.**

6ISS3 Provide 80 percent of FY 2006 planned on-orbit resources and accommodations to support research, including power, data, crew time, logistics and accommodations.

6ISS4 For FY 2006 ensure 90 percent functional availability for all ISS subsystems that support on-orbit research operations.

**Outcome 8.3: Reduce crew downtime due to health-related reasons during space flight missions.**

6SFS5 Achieve a 5 percent reduction in downtime.

**Outcome 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.**

6SFS6 Certify medical fitness of all crew members before launch.

6HSRT9 Complete renal stone countermeasure development.

6HSRT10 Start testing of bone and cardiovascular countermeasures in space.

**Outcome 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.

**Outcome 8.7: 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.

**Outcome 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 2 GeV per nucleon.

**NASA Objective 9: Conduct the first extended human expedition to the lunar surface as early as 2015, but no later than 2020.**

**NASA Objective 10: Conduct human expeditions to Mars after acquiring adequate knowledge about the planet using robotic missions and after successfully demonstrating sustained human exploration missions to the Moon.**

### **NASA Objective 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.**

#### **Outcome 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 percent 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).

#### **Outcome 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.

#### **Outcome 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.

#### **Outcome 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.

#### **Outcome 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.

#### **Outcome 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.

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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.

### **Outcome 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.

### **Outcome 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 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.

### **Outcome 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.

## **NASA Objective 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.**

### **Outcome 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)

### **Outcome 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 4 dB noise reduction. (VSP)

### **Outcome 12.4: By 2010, flight demonstrate an aircraft that produces no CO<sub>2</sub> or NO<sub>x</sub> to reduce smog and lower atmospheric ozone.**

6AT11 Complete trade study of unconventional propulsion concepts for a zero-emissions vehicle. (VSP)

### **Outcome 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)

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**Outcome 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 U.S. 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)

**Outcome 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)

**Outcome 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)

**NASA Objective 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.**

**Outcome 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)

**Outcome 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)

**Outcome 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)

**Outcome 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 percent of NASA's approved learning materials to be delivered using technology-enabled learning systems. (e-Ed)

**Outcome 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)

**NASA Objective 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.**

**Outcome 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.

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

6ESS3 Keep 90 percent 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 percent 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).

**Outcome 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.

**Outcome 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.

**NASA Objective 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.**

**Outcome 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).



### **Outcome 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.

### **Outcome 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).

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

### **Outcome 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.

## **NASA Objective 16: Pursue opportunities for international participation to support U.S. space exploration goals.**

## **NASA Objective 17: Pursue commercial opportunities for providing transportation and other services supporting International Space Station and exploration missions beyond Earth orbit. Separate to the maximum extent practical crew from cargo.**

### **Outcome 17.1: By 2010, provide 80 percent of optimal ISS up-mass, down-mass, and crew availability using non-Shuttle crew and cargo services.**

6ISS2 Down select transportation service providers from FY 2005 ISS Cargo Acquisition RFP.

## **NASA Objective 18: Use U.S. commercial space capabilities and services to fulfill NASA requirements to the maximum extent practical and continue to involve, or increase the involvement of, the U.S. private sector in design and development of space systems.**

## Efficiency Measures

### Solar System Exploration

- 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.

### The Universe

- 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.

### Earth-Sun System

- 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.

### Constellation Systems

- 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.

### Exploration Systems Research and Technology

- 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.

### Prometheus Nuclear Systems and Technology

- 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.

### Human Systems Research and Technology

- 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.

### Aeronautics Technology

- 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.

### Education Programs

- 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.

## **FY 2006 Performance Plan**

### **International Space Station**

6ISS5 Complete all development projects within 110% of the cost and schedule baseline.

6ISS6 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

### **Space Shuttle**

6SSP2 Complete all development projects within 110% of the cost and schedule baseline.

6SSP3 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

### **Space and Flight Support**

6SFS7 Complete all development projects within 110% of the cost and schedule baseline.

6SFS8 Deliver at least 90% of scheduled operating hours for all operations and research facilities.

6SFS9 Increase the throughput of the Space Network and NASA Wide Area Network per unit cost on an annual basis.

## Document Format

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Since the FY 2004 President's Budget submission, NASA has structured its budget by the major Themes, or portfolios, of the Agency. The format is designed to be easy to navigate and to present the costs and benefits of budget items consistently and clearly. The format also integrates the budget request and annual performance plan into one document. The FY 2006 President's Budget submission continues NASA's efforts to make the document increasingly clear and comprehensive.

## Budget Levels

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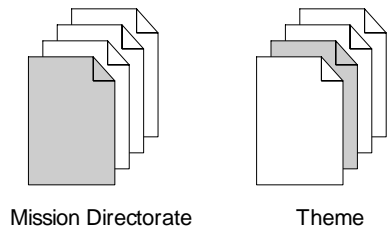
There are four budget levels. At the first level are the Mission Directorates, NASA's primary areas of activity. At the second are Themes, programmatic subdivisions of Mission Directorates that function as program "investment portfolios." At the third level, individual programs within the Themes are discussed. Projects are the fourth level. At each of the four budget levels, the document presents consistent types of information to allow comparison across the budget at that budget level and to facilitate document navigation.

### *Mission Directorates*

Mission Directorate sections provide a summary of each Directorate's purpose, recent and planned accomplishments, and overviews of each of its Themes.

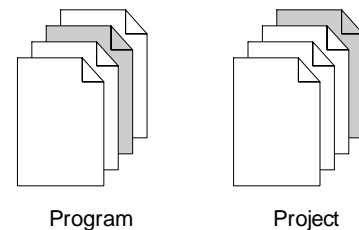
### *Themes*

To facilitate evaluation of the Theme as an investment, this section presents the "business case" for each Theme by displaying the budget request and discussing it in terms of the President's Research and Development Investment Criteria for relevance, quality, and performance. Theme sections include data on the programs that comprise the Theme. Also included are the Theme's performance commitments—the outcomes and annual performance goals that the Theme will accomplish—and information on independent reviews.



### *Programs*

Program descriptions include their plans for FY 2006, schedules of significant projects, major risks, formulation and development schedules, and key participants.



### *Projects*

Additional information for major projects (in formulation or development phases) is provided in the Supplementary Information volume. This information is intended to augment the budget request with additional information including schedule milestones, major acquisitions, risks, and development life-cycle costs.

## Acronyms

|       |   |         |   |
|-------|---|---------|---|
| AA    | Associate Administrator   | AT      | Aeronautics Technology (Theme)  |
| AAA   | Algorithms, Architectures, and Applications                                 | ATAC    | Air Transport Association of Canada   |
| AAH   | Advanced Animal Habitat   | ATC     | Air Traffic Control   |
| AATT  | Advanced Air Transportation Technologies                                    | ATCSCC  | Air Traffic Control System Command Center                                     |
| AC    | Advanced Concepts   | ATLO    | Assembly, Test, Launch Operations   |
| ACE   | Advanced Composition Explorer   | ATM     | Air Traffic Management  |
| ACRT  | Accelerated Crucible Rotation Technique                                     | ATMS    | Advanced Technology Microwave Sounder (NPOESS Preparatory Project instrument) |
| ACS   | Advanced Camera for Surveys (Hubble Space Telescope instrument)             | ATS     | Air Transportation System   |
| AEDC  | Arnold Engineering Development Center                                       | AVC     | Advanced Vehicle Concepts   |
| AESP  | Aerospace Education Services Program  | AvSSP   | Aviation Safety and Security Program  |
| AFRL  | Air Force Research Laboratory   | AWIPS   | Advanced Weather Interactive Processing System                                |
| AHMS  | Advanced Health Management System   | BAA     | Broad Agency Announcement   |
| AHST  | Advanced Human Support Technology   | BE      | Beyond Einstein (Program)   |
| AIA   | Atmospheric Imaging Assembly (Solar Dynamic Observatory instrument)         | BNL     | Brookhaven National Laboratory  |
| AIM   | Aeronomy of Ice in the Mesosphere   | BOA     | Basic Ordering Agreement  |
| AIRS  | Atmospheric Infrared Sounder  | BPRAC   | Biological and Physical Science Research Advisory Committee                   |
| AIST  | Advanced Information Systems Technology                                     | BPRE    | Biological and Physical Research Enterprise (former NASA Enterprise)          |
| AMMOS | Advanced Multi-Mission Operations System                                    | BPS     | Biomass Production System   |
| AMR   | Advanced Microwave Radiometer (Ocean Surface Topography Mission instrument) | BR      | Bioastronautics Research  |
| AO    | Announcement of Opportunity   | BR&C    | Biomedical Research and Countermeasures                                       |
| AOA   | Analysis of Alternatives  | BRP     | Biological Research Project   |
| AOS   | Airspace Operations Systems   | BSM     | Booster Separation Motors   |
| APG   | Annual Performance Goal   | BVT     | Breakthrough Vehicle Technologies   |
| APL   | Applied Physics Laboratory (Johns Hopkins University)                       | CAASD   | Center for Advanced Aviation System Development                               |
| APS   | Advanced Polarimeter Sensor (Glory instrument)                              | CADRE   | Crop Assessment Data Retrieval and Evaluation                                 |
| APT   | Advanced Platform Technology  | CAIB    | Columbia Accident Investigation Board   |
| AR&D  | Automated Rendezvous and Docking  | CALIPSO | Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations            |
| ARC   | Ames Research Center  | CAM     | Centrifuge Accommodations Module  |
| ARMD  | Aeronautics Research Mission Directorate                                    | CAN     | Cooperative Agreement Notice  |
| ARTCC | Air Route Traffic Control Center  | CARA    | California Association for Research in Astronomy                              |
| AS    | Airspace Systems  | CARD    | Cost Analysis Requirements Document   |
| ASEB  | Aeronautics and Space Engineering Board                                     | CAS     | Commercial Advisory Subcommittee  |
| ASI   | Agenzia Spaziale Italiana (Italian Space Agency)                            | CASA    | Carnegie, Ames, Stanford Approach   |
| ASO   | Astronomical Search for Origins (former NASA Theme)                         | CAST    | Commercial Aviation Safety Team   |
| ASP   | Airspace Systems Program  | CCAD    | Center for Computer-aided Design  |
| AST   | Advanced Space Transportation (Program)                                     | CCSP    | Climate Change Science Program  |
| ASVM  | Aircraft and Systems Vulnerability Mitigation                               |         |   |

## Acronyms

|         |  |         |  |
|---------|--|---------|--|
| CCU     | Cell Culture Unit  | CXO     | Chandra X-ray Observatory  |
| CDC     | Centers for Disease Control  | CY      | Calendar Year  |
| CDE     | Cosmic Dust Experiment (Aeronomy of Ice in the Mesosphere instrument)                | DAA     | Deputy Associate Administrator   |
| CDR     | Critical Design Review   | DAFT    | Dust and Aerosol Measurement Facility Test   |
| CE&R    | Concept Exploration and Refinement   | DARPA   | Defense Advanced Research Projects Agency  |
| CENR    | Committee on Environment and Natural Resources Research                              | DART    | Demonstration of Autonomous Rendezvous Technology  |
| CEOS    | Committee on Earth Observation Satellites  | DEVELOP | Digital Earth Virtual Environment and Learning Outreach Program  |
| CEV     | Crew Exploration Vehicle   | DFRC    | Dryden Flight Research Facility  |
| CFO     | Chief Financial Officer  | DHS     | Department of Homeland Security  |
| CHIPS   | Cosmic Hot Interstellar Plasma Spectrometer  | DI      | Deep Impact  |
| CHS     | Crew Health and Safety   | DLN     | Digital Learning Network   |
| CINDI   | Coupled Ion Neutral Dynamics Investigation   | DLR     | Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Center)  |
| CIPA    | Curriculum Improvement Partnership Awards  | DoD     | Department of Defense  |
| CIPS    | Cloud Imaging and Particle Size (Aeronomy of Ice in the Mesosphere instrument)       | DoE     | Department of Energy   |
| CIR     | Combustion Integrated Rack   | DORIS   | Doppler Orbitography by Radiopositioning Integrated by Satellite (Ocean Surface Topography Mission instrument) |
| CIRA    | Cooperative Institute for Research in the Atmosphere                                 | DoT     | Department of Transportation   |
| CLV     | Crew Launch Vehicle  | DPR     | Dual-frequency Precipitation Radar (Global Precipitation Mission instrument)                                   |
| CMAQ    | Community Multiscale and Air Quality   | DSMS    | Deep Space Mission System  |
| CMB     | Cosmic Microwave Background  | DSN     | Deep Space Network   |
| CME     | Coronal Mass Ejection  | DST     | Decision Support Tool  |
| CNES    | Centre Nationale D'Etudes Spatiale (French Space Agency)                             | DPR     | Dual-Frequency Precipitation Radar   |
| CNS     | Communication, Navigation, and Surveillance  | EAS     | Efficient Aircraft Spacing   |
| CO2     | Carbon Dioxide   | EASI    | Efficient Aerodynamic Shapes and Integration   |
| CoF     | Construction of Facilities   | ECLSS   | Environmental Control and Life Support System  |
| COMPLEX | Committee on Planetary and Lunar Exploration   | ECR     | Environmental Compliance and Restoration   |
| CONAE   | Argentina's National Committee of Space Activities                                   | ECT     | Enabling Concepts and Technologies   |
| CONTOUR | Comet Nucleus Tour   | EDL     | Entry, Descent, and Landing  |
| COTF    | Classroom of the Future  | EELV    | Evolved Expendable Launch Vehicle  |
| CPR     | Cloud Profiling Radar (Cloudsat instrument)  | EFI     | Electric Field Instrument (Thermal Emission Imaging System instrument)   |
| CQUEST  | Carbon Query and Evaluation Support Tools  | EFMP    | Efficient Flight Path Management   |
| CrIS    | Cross-track Infrared Sounder (an NPOESS Preparatory Project instrument)              | EFPM    | Efficient Flight Path Management   |
| CRISM   | Compact Reconnaissance Imaging Spectrometer (Mars Reconnaissance Orbiter instrument) | EIS     | Extreme-ultraviolet Imaging Spectrometer (Solar-B instrument)  |
| CSA     | Canadian Space Agency  | ELV     | Expendable Launch Vehicle  |
| CSOC    | Consolidated Space Operations Contract   | ELVIS   | Expendable Launch Vehicle Integrated Support   |
|         |  | EOS     | Earth Observing System   |

## Acronyms

|          |  |        |   |
|----------|--|--------|---|
| EOSDIS   | Earth Observing System Data and Information System                                 | FR     | Flight Rule   |
| EPA      | Environmental Protection Agency  | FSB    | Fundamental Space Biology (former NASA Theme)                                   |
| EPMC     | Enterprise Program Management Council  | FUSE   | Far Ultraviolet Spectroscopic Explorer  |
| EPSCoR   | Experimental Program to Stimulate Competitive Research                             | FY     | Fiscal Year   |
| ESA      | European Space Agency  | GAJSC  | General Aviation Joint Steering Committee                                       |
| ESE      | Earth Science Enterprise (former NASA Enterprise)                                  | GALEX  | Galaxy Evolution Explorer   |
| ESMD     | Exploration Systems Mission Directorate  | GAO    | Government Accountability Office  |
| ESMF     | Earth Science Model Framework  | GASMAP | Gas Analyzer System for Metabolic Analysis Physiology                           |
| ESR&T    | Exploration Systems Research and Technology (Theme)                                | GBM    | Gamma-ray Burst Monitor (Gamma-ray Large Area Telescope instrument)             |
| ESS      | Earth-Sun System (Theme)   | GE     | General Electric  |
| ESSD     | Earth Sciences and Applications Division (former NASA Theme)                       | GEC    | Global Electrodynamics Connection   |
| ESSP     | Earth System Science Pathfinder  | GHz    | Gigahertz   |
| ESTO     | Earth Science Technology Office  | GIS    | Geographic Information System   |
| ESTP     | Earth Science Technology Program   | GLAST  | Gamma-ray Large Area Space Telescope  |
| ET       | External Tank  | GLOBE  | Global Learning and Observations to Benefit the Environment                     |
| ETA      | External Tank Assembly   | GM     | Geospace Missions   |
| ETF      | Environmental Test Facility  | GM-ITM | Geospace Mission-Ionosphere-Thermosphere Mapper                                 |
| ETM      | Enhanced Thematic Mapper   | GMI    | GPM Microwave Imager (Global Precipitation instrument)                          |
| ETU      | Engineering Test Unit  | GO     | Guest Observers   |
| EUMETSAT | European Organization for the Exploitation of Meteorological                       | GOES   | Geostationary Operational Environmental Satellite                               |
| EUV      | Extreme Ultraviolet  | GP-B   | Gravity Probe-B   |
| EVA      | Extravehicular Activity  | GPM    | Global Precipitation Measurement  |
| EVE      | Extreme-ultraviolet Variability Experiment (Solar Dynamics Observatory instrument) | GPMC   | Governing Program Management Council  |
| EXPRESS  | Expedite the Processing of Experiments to the Space Station                        | GPS    | Global Positioning System   |
| F&SD     | Flight and Systems Demonstration   | GPSP   | Global Positioning System Payload (Ocean Surface Topography Mission instrument) |
| FAA      | Federal Aviation Administration  | GRACE  | Gravity Recovery and Climate  |
| FAD      | Formulation Authorization Document   | GRB    | Gamma Ray Burst   |
| FAST     | Fast Auroral Snapshot  | GRC    | Glenn Research Center   |
| FEMA     | Federal Emergency Management Agency  | GSFC   | Goddard Space Flight Center   |
| FFP      | Focal Plane Package (Solar-B instrument)   | GSRP   | Graduate Student Research Program   |
| FFRDCs   | Federally Funded Research and Development Centers                                  | GSS    | Ground Support Systems  |
| FGM      | Fluxgate Magnetometer (Thermal Emission Imaging System instrument)                 | GSSR   | Goldstone Solar System Radar  |
| FGS      | Fine Guidance Sensor   | H&RT   | Human and Robotic Technology (former NASA Theme)                                |
| FIR      | Fluids Integrated Rack   | HABSOS | Harmful Algae Blooms Observing System   |
| FPGA     | Field Programmable Gate Array  | HALE   | High-altitude, Long-endurance   |
| FPP      | Freon Pump Package   |        |   |

## Acronyms

|          |  |         |  |
|----------|--|---------|--|
| HALE-ROA | High-altitude, Long-endurance Remotely Operated Aircraft   | ISRO    | Indian Space Research Organisation   |
| HAZUS    | Hazards U.S.   | ISS     | International Space Station  |
| HBCU     | Historically Black Colleges and Universities   | ISTP    | Integrated Space Transportation Plan   |
| HETE-2   | High Energy Transient Explorer   | ITAR    | International Traffic in Arms Regulation                                       |
| HMI      | Helioseismic and Magnetic Imager (Solar Dynamic Observatory instrument)                                      | ITAS    | Integrated Tailored Aerostructures   |
| HMP      | Human Measures and Performance   | ITF     | Integrated Training Facility   |
| HQ       | NASA Headquarters  | ITM     | Ionspheric/Thermospheric/Mesospheric   |
| HRF      | Human Research Facility  | ITTP    | Innovative Technology Transfer Partnerships                                    |
| HRI      | High Resolution Imager   | IWGEO   | Interagency Working Group on Earth Observations                                |
| HRT      | High Resolution Tracker  | JACIE   | Joint Agency Committee for Imagery Evaluation                                  |
| HSI      | Human Systems Integration  | JAXA    | Japanese Aerospace Exploration Agency  |
| HSR&T    | Human Systems Research and Technology (Theme)  | JDEM    | Joint Dark Energy Mission  |
| HST      | Hubble Space Telescope   | JEM     | Japanese Experiment Module   |
| I&T      | Integration and Test   | JHU     | John Hopkins University  |
| IAA      | International Academy of Astronautics  | JHU-APL | Johns Hopkins University—Applied Physics Laboratory                            |
| IAIPT    | Interagency ATM Integrated Product Team  | JIMO    | Jupiter Icy Moons Orbiter  |
| IAT      | Independent Assessment Team  | JPDO    | Joint Planning and Development Office  |
| IBPD     | Integrated Budget and Performance Document   | JPL     | Jet Propulsion Laboratory  |
| ICAO     | International Civil Aviation Organization  | JSC     | Johnson Space Center   |
| IGA      | Intergovernmental Agreement  | JSRA    | Joint Sponsored Research Agreement   |
| IIR      | Imaging Infrared Radiometer (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations instrument)  | JSRDA   | Joint Sponsored Research and Development Agreement                             |
| IMAGE    | Imager for Magnetopause-to-Aurora Global Exploration   | JWG     | Joint Working Group  |
| IMP-8    | Interplanetary Monitoring Platform 8   | JWST    | James Webb Space Telescope   |
| IMPACT   | In-situ Measurements of Particles and CME Transients (Solar Terrestrial Relations Observatory investigation) | KI      | Keck Interferometer  |
| INTEGRAL | International Gamma Ray Astrophysics Laboratory  | KSC     | Kennedy Space Center   |
| IPAO     | Independent Program Assessment Office  | kW      | Kilowatt   |
| IPO      | Integrated Program Office  | LANL    | Los Alamos National Laboratory   |
| IPS      | Intelligent Propulsion System  | LaRC    | Langley Research Center  |
| IRA      | Institutional Research Awards  | LASP    | Laboratory for Atmospheric and Space Physics (University of Colorado, Boulder) |
| IRT      | Independent Review Team  | LAT     | Large Area Telescope (Gamma-ray Large Area Telescope instrument)               |
| ISAS     | Institute of Space and Astronautical Science   | LBTI    | Large Binocular Telescope Interferometer                                       |
| ISFS     | Invasive Species Forecasting System  | LCC     | Life-cycle Cost  |
| ISHM     | Integrated System Health Management  | LDCM    | Landsat Data Continuity Mission  |
| ISOR     | Independent Science and Operations Review  | LE      | Lunar Exploration  |
| ISPP     | In-space Propulsion Program  | LEAP    | Low Emissions Alternative Power  |
|          |  | LEO     | Low Earth Orbit  |
|          |  | LIDAR   | Light Detection and Ranging  |
|          |  | LiOH    | Lithium Hydroxide  |



## Acronyms

|           |  |           |  |
|-----------|--|-----------|--|
| LISA      | Laser Interferometer Space Antenna                                       | MRO       | Mars Reconnaissance Orbiter  |
| LMA       | Lockheed Martin Astronautics   | MRR       | Mission Requirement Request  |
| LOA       | Letter of Agreement  | MSFC      | Marshall Space Flight Center   |
| LOI       | Lunar Orbit Injection  | MSI       | Minority-serving Institute   |
| LRA       | Laser Retroreflector Array (Ocean Surface Topography Mission instrument) | MSL       | Mars Science Laboratory  |
| LRD       | Launch Readiness Date  | MSMT      | Mission and Science Measurement Technology   |
| LSG       | Life Sciences Glovebox   | MSR       | Mars Sample Return   |
| LTMPF     | Low Temperature Microgravity Physics Facility                            | MSRF      | Materials Science Research Facility  |
| LTP       | Learning Technologies Project  | MSRR      | Materials Science Research Rack  |
| LWS       | Living with a Star (Program)   | MTO       | Mars Telesat Orbiter   |
| MASTAP    | Mathematics and Science Teacher Partnership Program                      | MUREP     | Minority University Research and Education Program                                     |
| MAV       | Mars Ascent Vehicle  | MUSES - C | Mu Space Engineering Spacecraft-C  |
| MCC       | Mission Control Center   | MUSS      | Multi-user Systems and Support   |
| MCR       | Mission Confirmation Review  | MXER      | Momentum Exchange/Electrodynamic Reboost   |
| McTMA     | Multi-center Traffic Management Advisor                                  | NAC       | NASA Advisory Committee  |
| MEP       | Mars Exploration Program   | NAPA      | National Academy of Public Administration  |
| MEPAG     | Mars Exploration Program Analysis Group                                  | NAR       | Non-advocacy Review  |
| MER       | Mars Exploration Rover   | NAS       | National Airspace System   |
| MESSENGER | Mercury Surface, Space Environment, Geochemistry and Ranging             | NASDA     | National Space Development Agency of Japan   |
| MGS       | Mars Global Surveyor   | NAST      | NPOESS Aircraft Sounder Testbed  |
| MIDEX     | Medium-size Explorer   | NEA       | NASA Educator Astronaut  |
| MILA      | Merritt Island Launch Annex  | NEAR      | Near-Earth Asteroid Rendezvous   |
| MIRI      | Mid-infrared Instrument (James Webb Space Telescope instrument)          | NEI       | NASA Explorer Institute  |
| MISR      | Multi-angle Imaging Spectroradiometer                                    | NEMS      | NASA Equipment Management System   |
| MIT       | Massachusetts Institute of Technology                                    | NEO       | Near-Earth Object  |
| MLCD      | Mars Laser Communication Demonstration                                   | NEP       | Nuclear Electric Propulsion  |
| MLP       | Mobile Launch Platform   | NEPA      | National Environmental Policy Act  |
| MMRTG     | Multi-missions Radioisotope Thermoelectric Generators                    | NEXT      | Next-generation Electric Propulsion  |
| MMS       | Magnetospheric Multiscale  | NEXTNAS   | NASA Exploratory Technologies for the National Airspace System                         |
| MO        | Missions of Opportunity  | NGLT      | Next Generation Launch Technology  |
| MO&DA     | Mission Operations and Data Analysis                                     | NIAC      | NASA Institute of Advanced Concepts  |
| MOA       | Memorandum of Agreement  | NICMOS    | Near Infrared Camera and Multi-object Spectrometer (Hubble Space Telescope instrument) |
| MODIS     | Moderate-resolution Imaging Spectroradiometer                            | NIH       | National Institutes of Health  |
| MOI       | Mission Orbit Insertion  | NIMA      | National Imagery and Mapping Agency  |
| MOU       | Memorandum of Understanding  | NIRCam    | Near-infrared Camera (James Webb Space Telescope instrument)                           |
| MPIAT     | Mars Program Independent Assessment Team                                 | NIRSpec   | Near Infrared Spectrometer (James Webb Space Telescope instrument)                     |
| MPLM      | Multi-purpose Logistic Module  | NISN      | NASA Integrated Services Network   |

## Acronyms

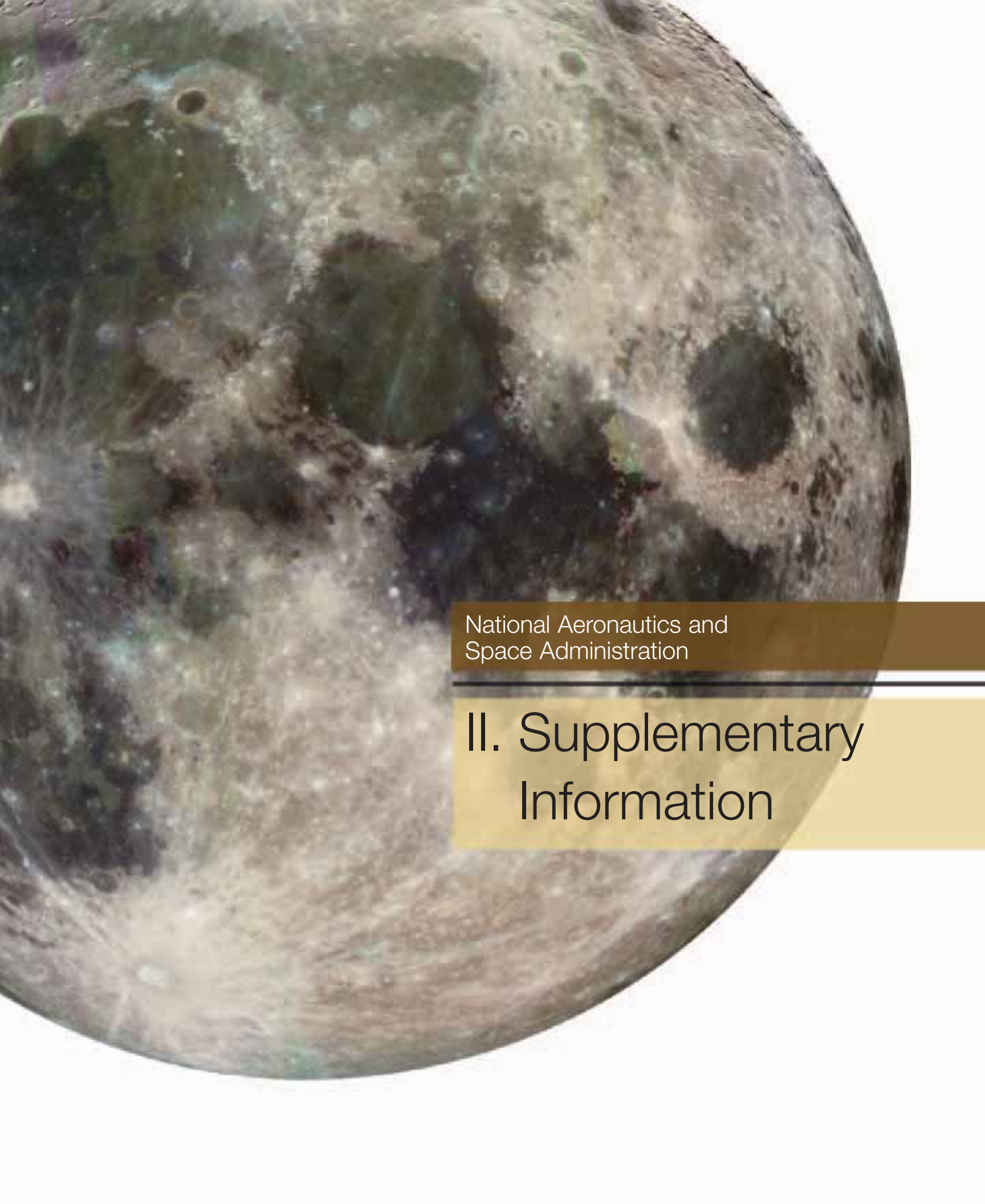
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| NIWA   | National Institute for Water and Atmospheric Research                    | PAIR      | Partnership Awards for the Integration of Research into Undergraduate Education                      |
| NLS    | NASA Launch Services   | PART      | Program Assessment Rating Tool   |
| NLT    | NASA Learning Technologies   | PBS       | President's Budget Submit  |
| NMP    | New Millennium Program   | PCA       | Program Commitment Agreement   |
| NOAA   | National Oceanic and Atmospheric Administration                          | PCS       | Physics of Colloids in Space   |
| NOx    | Nitrogen Oxide   | PDR       | Preliminary Design Review  |
| NPOESS | National Polar-orbiting Operational Environmental Satellite System       | PDS       | Passive Dosimeter System   |
| NPG    | Nuclear Power Generation   | PER       | Pre-Environmental Review   |
| NPP    | NPOESS Preparatory Project   | PI        | Principal Investigator   |
| NPR    | NASA Procedural Requirement  | PIMC      | Program Institutional Management Council   |
| NRA    | NASA Research Announcement   | PKB       | Pluto-Kuiper Belt (New Horizons)   |
| NRC    | Nuclear Regulatory Commission  | PLASTIC   | Plasma and Supra-thermal Ion and Composition (Solar Terrestrial Relations Observatory investigation) |
| NRO    | National Reconnaissance Office   | PMC       | Program Management Council   |
| NRTS   | Network Resources Training Site  | PMSR      | Preliminary Mission System Review  |
| NSBRI  | National Space Biomedical Research Institute                             | POES      | Polar Operational Environmental Satellites   |
| NSCORS | NASA Specialized Centers of Research                                     | POIC      | Payloads Operations Information Center   |
| NSF    | National Science Foundation  | POIF      | Payloads Office Integration Function   |
| NSRDB  | National Solar Radiation Data Base                                       | PRU       | Plant Research Unit  |
| NSRL   | NASA Space Radiation Laboratory  | PSO       | Primary Science Orbit  |
| NTTC   | National Technology Transfer Center                                      | PSR       | Physical Sciences Research   |
| OBPR   | Office of Biological and Physical Research                               | PSU       | Pennsylvania State University  |
| OBSS   | Orbiter Boom Sensor System   | QAT       | Quiet Aircraft Technology  |
| OCO    | Orbiting Carbon Observatory  | RASC      | Revolutionary Aero Space Concepts  |
| ODA    | Orbital Debris Assessment  | RBM       | Radiation Belt Mapper Mission  |
| OIG    | Office of Inspector General  | REASoN    | Research, Education and Applications Solutions Network   |
| OLI    | Operational Land Imager (Landsat Data Continuity Mission instrument)     | RETScreen | Renewable Energy Technology (Renewable Energy Project Analysis Software)                             |
| OMB    | Office of Management and Budget  | RFP       | Request for Proposal   |
| OMI    | Ozone Measuring Instrument   | RHESSI    | Reuven Ramaty High Energy Solar Spectroscopic Imager   |
| OMM    | Orbiter Major Modifications  | RLE       | Robotic Lunar Exploration (Program)  |
| OMPS   | Ozone Mapping and Profiler Suite (NPOESS Preparatory Project instrument) | ROA       | Remotely Operated Aircraft   |
| OMU    | Other Minority Universities  | ROSES     | Research Opportunities in Space and Earth Science  |
| OPF    | Orbiter Processing Facility  | ROSS      | Research Opportunities In Space Science  |
| ORR    | Operations Readiness Review  | RPC       | Research Partnership Center  |
| ORU    | Orbital Replacement Unit   | RPCT      | Radioisotope Power Conversion Technology   |
| OSP    | Orbital Space Plane  | RPS       | Radioisotope Power System  |
| OSS    | Office of Space Science (former NASA office)                             | RPT       | Rocket Propulsion Testing  |
| OSTM   | Ocean Surface Topography Mission   | RSA       | Russian Space Agency   |

## Acronyms

|         |   |        |   |
|---------|---|--------|---|
| RSB     | Rudder Speed Brake  | SM 4   | Servicing Mission 4   |
| RSDO    | Rapid Spacecraft Development Office   | SMD    | Science Mission Directorate   |
| RSRM    | Reusable Solid Rocket Motor   | SMEX   | Small Explorer  |
| RTF     | Return to Flight  | SMO    | Systems Management Organization   |
| RXTE    | Rossi X-ray Timing Explorer   | SMPMC  | Systematic Measurements Program Management Council                                  |
| S&MA    | Safety and Mission Assurance  | SMS    | Science Measurement Systems   |
| SAC-D   | Satellite de Aplicaciones Cientificas–D (Argentina)   | SN     | Space Network   |
| SAME    | Smoke and Aerosol Measurement Experiment  | SOA    | State of the Art  |
| SAMPEX  | Solar Anomalous and Magnetospheric Particle Explorer  | SOFIA  | Stratospheric Observatory for Infrared Astronomy                                    |
| SAO     | Smithsonian Astrophysical Observatory   | SOFIE  | Solar Occultation for Ice Experiment (Aeronomy of Ice in the Mesosphere instrument) |
| SAR     | Synthetic Aperture Radar  | SOHO   | Solar Heliospheric Observer   |
| SATS    | Small Aircraft Transportation System  | SOMD   | Space Operations Mission Directorate  |
| SATSLab | Small Aircraft Transportation System Laboratory   | SORCE  | Solar Radiation and Climate Experiment  |
| SAU     | Strategic Airspace Usage  | SPD    | Space Product Development   |
| SBIR    | Small Business Innovative Research  | SPF    | Software Production Facility  |
| SBT     | Space-based Technology  | SPP    | Science Power Platform  |
| SCM     | Search Coil Magnetometer (Thermal Emission Imaging System instrument)   | SPRL   | Space Physics Research Laboratory   |
| SDO     | Solar Dynamics Observatory  | SRB    | Solid Rocket Booster  |
| SDR     | System Design Review  | SRG    | Stirling Radioisotope Generator   |
| SEC     | Sun–Earth Connection (former NASA Theme)  | SRR    | Systems Requirement Review  |
| SECAS   | Sun–Earth Connection Advisory Subcommittee  | SSB    | Space Studies Board   |
| SECCHI  | Sun-Earth Connection Coronal and Heliospheric Investigation (Solar Terrestrial Relations Observatory investigation) | SSBRP  | Space Station Biological Research Project   |
| SELENE  | Selenological and Engineering Explorer (Japan)  | SSC    | Stennis Space Center  |
| SERVIR  | Central American Monitoring and Visualization System  | SScAC  | Space Science Advisory Committee  |
| SEU     | Structure and Evolution of the Universe (former NASA Theme)   | SSE    | Solar System Exploration (Theme)  |
| SFLC    | Space Flight Leadership Council   | SSES   | Solar System Exploration Subcommittee   |
| SFOC    | Space Flight Operations Contract  | SSME   | Space Shuttle Main Engines  |
| SFS     | Space and Flight Support  | SSMOC  | SOFIA Science and Mission Operations Center   |
| SHARAD  | Shallow Radar   | SSP    | Space Shuttle Program   |
| SHARP   | Summer High-school Apprenticeship Research Program  | SSS    | Sea Surface Salinity  |
| SHARPP  | Solar Heliospheric Activity Research and Prediction Program   | SST    | Solid State Telescope (Thermal Emission Imaging System instrument)                  |
| SIM     | Space Interferometry Mission  | STEM   | Science, Technology, Engineering, and Mathematics                                   |
| SLAC    | Stanford Linear Accelerator Center  | STEREO | Solar Terrestrial Relations Observatory   |
| SLEP    | Shuttle Service Life Extension Program  | STIS   | Space Telescope Imaging Spectrograph (Hubble Space Telescope instrument)            |
|         |   | STP    | Solar Terrestrial Probes (Program)  |
|         |   | STS    | Space Transportation System   |
|         |   | STScI  | Space Telescope Science Institute   |

## Acronyms

|        |  |       |   |
|--------|--|-------|---|
| STSP   | Science and Technology Scholarship Program                       | URETI | University Research Engineering, and Technology Institute   |
| STTR   | Small Business Technology Transfer Program                       | USAF  | United States Air Force   |
| SVA    | Strategic Vehicle Architecture                                   | USDA  | United States Department of Agriculture   |
| SVD    | System Vulnerability Detection                                   | USFS  | United States Forest Service  |
| SVS    | Synthetic Vision System  | USGS  | United States Geological Survey   |
| SWEPT  | System-wide Evaluation and Planning Tool                         | USRA  | Universities Space Research Association   |
| SWMF   | Space Weather Modeling Framework                                 | USRP  | Undergraduate Student Research Program  |
| SWOT   | Strengths, Weaknesses, Opportunities, and Threats                | VAB   | Vehicle Assembly Building   |
| SwRI   | Southwest Research Institute                                     | VAMS  | Virtual Airspace Modeling and Simulation  |
| TCAT   | 21st Century Aircraft Technology Project                         | VAS   | Visible and Infrared Atmospheric Sounder (Geostationary Operational Environmental Satellite instrument) |
| TCU    | Tribal Colleges and Universities                                 | VAST  | Virtual Airspace Simulation Technology  |
| TDRS   | Tracking and Data Relay Satellite                                | VIIRS | Visible-infrared Imager Radiometer Suite (NPOESS Preparatory Project instrument)                        |
| TDRSS  | Tracking and Data Relay Satellite System                         | VLTI  | Very Large Telescope Interferometer   |
| TFM    | Traffic Flow Management  | VPCAR | Vapor Phase Catalytic Ammonia Removal   |
| THEMIS | Thermal Emission Imaging System                                  | VSP   | Vehicle Systems Program   |
| TIM    | Total Irradiance Monitor (Glory instrument)                      | WATR  | Western Aeronautical Test Range   |
| TIMED  | Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics    | WAVES | Radio and Plasma Waves Instrument (Wind)  |
| TMP    | Technology Maturation Program                                    | WFC 3 | Wide Field Camera (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations instrument)       |
| TOMS   | Total Ozone Mapping Spectrometer                                 | WFS&C | Wave Front Sensing and Control (James Webb Space Telescope instrument)                                  |
| TOPEX  | Ocean Topographic Experiment                                     | WGA   | Western Governors Association   |
| TPF    | Terrestrial Planet Finder  | WISE  | Widefield Infrared Survey Explorer  |
| TRACE  | Transition Region and Coronal Explorer                           | WJHTC | William J. Hughes Technical Center  |
| TRL    | Technology Readiness Level                                       | WMAP  | Wilkinson Microwave Anisotropy Probe  |
| TRMM   | Tropical Rainfall Measuring Mission                              | WORF  | Window Observational Research Facility  |
| TSA    | Transportation Security Administration                           | WPA   | Water Processor Assembly  |
| TWINS  | Two Wide-angle Imaging Neutral-atom Spectrometers                | WRF   | Weather Research Forecasting  |
| UARC   | Upper Atmosphere Research Collaboratory                          | WRS   | Water Recycling System  |
| UAV    | Unmanned Aerial Vehicle  | WSOA  | Wide Swath Ocean Altimeter (Ocean Surface Topography Mission instrument)                                |
| UEET   | Ultra-efficient Engine Technology                                | WSTF  | White Sands Test Facility   |
| UHF    | Ultra High Frequency   | XMM   | X-ray Multi-mirror Mission  |
| ULF    | Utilization and Logistics Flight                                 | XRT   | X-ray Telescope (Solar-B instrument)  |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |       |   |
| URC    | University Research Center                                       |       |   |



National Aeronautics and  
Space Administration

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## II. Supplementary Information

### Overview

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This Supplementary Information Volume provides additional information on the major projects in formulation or development phases as identified in the budget request and is organized by Directorates and Themes.

The formulation phase includes all activities prior to a formal commitment by the Agency to proceed into full development. This commitment is granted only after development of independent cost estimates, completion of a non-advocacy review, establishment of a life-cycle cost baseline, and the signing of a formal Program Commitment Agreement. This step usually occurs after completion of the preliminary design review.

The development phase includes design, development, testing, and evaluation, and commences with the signing of the Program Commitment Agreement, and completes with launch or delivery of the product. During the development phase, a project must meet specific technical requirements and substantiate its life-cycle cost projections.

Each project section provides an Overview section describing the scope and objectives of the project and gives a broad picture of what the project will accomplish and its benefits. The organization responsible for project management is listed in the Program Management section. The Technical Description section provides project details, including how the project objectives will be accomplished. This section also includes a description of all the elements of the project and a summary of work being performed in these elements. The Schedule section includes key project milestones with dates and any changes from the FY 2005 plan. The section on Strategy for Major Planned Acquisitions lists future major acquisitions, including planned announcements and acquisition goals (e.g., full and open competition, directed work, or partnerships). The Risk Management section lists key known risks and strategies to mitigate these risks. The Budget section provides only the FY 2006 request for projects in formulation that do not yet have an established life cycle baseline, or the entire life-cycle cost baseline for all development projects.

Under full cost, NASA allocates all costs to its programs, including general and administrative (G&A) costs from the Centers and the Agency (corporate G&A). The project costs shown in this Supplementary Information Volume include all direct costs, but only the G&A costs from the Centers performing the work. Corporate G&A is not allocated to the projects in these reports. Since corporate allocations are solely based upon total program costs, project manager decisions are not influenced by allocation of corporate overhead. For each of these projects, the allocation by year of corporate overhead can easily be calculated.

## SCIENCE

### Solar System Exploration

Appendix - SAE 2-1

DAWN  
NEW HORIZONS  
MARS RECONNAISSANCE ORBITER 2005 (MRO)  
PHOENIX (SCOUT 07)  
2009 MARS SCIENCE LABORATORY  
2009 MARS TELECOMMUNICATIONS ORBITER  
LUNAR RECONNAISSANCE ORBITER (LRO)

### The Universe

Appendix - SAE 3-1

KECK  
SPACE INTERFEROMETRY MISSION (SIM)  
JAMES WEBB SPACE TELESCOPE  
STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)  
GAMMA-RAY LARGE AREA SPACE TELESCOPE (GLAST)  
KEPLER  
WIDE-FIELD INFRARED SURVEY EXPLORER (WISE)  
HERSCHEL  
PLANCK

### Earth-Sun System

Appendix - SAE 4-1

OCEAN SURFACE TOPOGRAPHY MISSION  
NPOESS PREPARATORY PROJECT (NPP)  
GLOBAL PRECIPITATION MISSION  
GLORY  
LANDSAT DATA CONTINUITY MISSION (LDCM)  
SOLAR DYNAMIC OBSERVATORY  
SOLAR TERRESTRIAL RELATIONS OBSERVATORY (STEREO)  
SOLAR-B  
AERONOMY OF ICE IN THE MESOSPHERE (AIM)  
THERMAL EMISSION IMAGING SYSTEM (THEMIS)  
CLOUDSAT  
CLOUD-AEROSOL LIDAR AND INFRARED PATHFINDER SATELLITE OBSERVATIONS (CALIPSO)  
ORBITING CARBON OBSERVATORY  
HYDROS  
AQUARIUS

## EXPLORATION SYSTEMS

### Constellation Systems

Appendix - SAE 6-1

CREW EXPLORATION VEHICLE (SPIRAL 1)  
CREW LAUNCH VEHICLE (SPIRAL 1)

**SPACE OPERATIONS**

**International Space Station**

**Appendix - EC 2-1**

CORE DEVELOPMENT

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM (ECLSS)

ISS CARGO AND CREW SERVICES



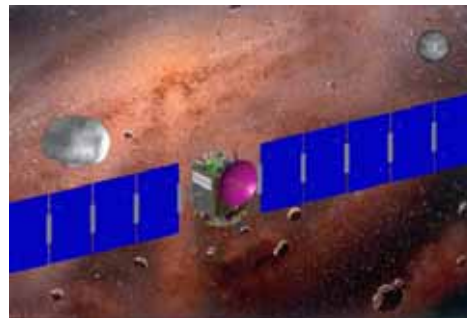
**Theme:** Solar System Exploration  
**Program:** Discovery  
**Project In Development:** Dawn

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

| Dawn                         | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 126.5  | 78.2   | 49.2   | 6.2    | 5.7    | 5.9    | 7.0    |
| Changes from FY 2005 Request | 1.6    | -6.2   | 5.4    | 0.1    | -0.7   | -0.8   |        |

**Overview**

The Dawn mission's primary objective is to significantly increase our understanding of the conditions and processes present during the solar system's earliest history by investigating in detail two of the largest protoplanets remaining intact since their formation. Specifically, the spacecraft will examine the geophysical and geochemical properties of 1 Ceres and 4 Vesta; main belt asteroids that reside between Mars and Jupiter. This will be accomplished by sending a spacecraft to orbit these asteroids and perform science investigations using imaging, spectroscopy, and gravity measurements.



Currently in development phase: Life-Cycle-Cost (LCC) data provided and NASA is committed to the LCC estimate.

The Dawn Homepage can be accessed at:  
<http://dawn.jpl.nasa.gov>

An artist's rendition of Dawn with Vesta and Ceres.

**Changes From FY 2005**

- The laser altimeter and magnetometer instruments were deleted, and a one month launch delay (from May 2006 to June 2006) in order to fit the mission within its cost cap and funding profile.
- Vesta Encounter reduced from 11 months to 7 months, and Ceres Encounter reduced from 11months to 5 months.

**Program Management**

The JPL is responsible for Dawn project management.

**Technical Description**

Dawn has a focused set of science and measurement objectives to be obtained through radio science and three instruments. The mission launches in June 2006 and uses solar-electric propulsion to reach and orbit Vesta (for seven months) and Ceres for (five months), while performing science investigations at various altitudes and lighting conditions. The use of solar-electric propulsion readily mitigates launch injection errors and is used during the interplanetary cruise to match trajectories with the asteroid. Dawn uses a maximum of one ion thruster operating at a time (there are three thrusters on the spacecraft). Stay times at Vesta and Ceres can easily be extended. The total mission duration is nine years.

**Theme:** Solar System Exploration  
**Program:** Discovery  
**Project In Development:** Dawn

### Schedule

| Date    | Key Milestones                 | Change From FY 2005            |
|---------|--------------------------------|--------------------------------|
| 9/2002  | Start of Formulation           | None                           |
| 10/2003 | Preliminary Design Review      | None                           |
| 5/2004  | Mission Critical Design Review | None                           |
| 6/2006  | Launch                         | Slip one month (from May 2006) |
| 10/2011 | Vesta Encounter                | None                           |
| 8/2015  | Ceres Encounter                | None                           |
| 8/2016  | End of Mission                 | None                           |

### Strategy For Major Planned Acquisitions

- All major acquisitions are in place.

### Key Participants

- The German Aerospace Center (DLR) provides the framing camera instrument.
- JPL is responsible for project management and mission operations.
- The Italian Space Agency (ASI) is responsible for the Mapping Spectrometer.
- Los Alamos National Labs is providing the GRAND instrument.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC  | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|------|-------|----------|
| FY 2006 PRES BUD          | 37.8  | 126.5  | 78.2   | 49.2   | 6.2    | 5.7    | 5.9    | 7.0    | 47.3 | 363.8 |          |
| Changes                   | 0.0   | 1.6    | -6.2   | 5.4    | 0.1    | -0.7   | -0.8   |        | -9.0 | -2.6  |          |
| FY2005 President's Budget | 37.8  | 124.9  | 84.4   | 43.8   | 6.1    | 6.4    | 6.7    |        | 56.3 | 366.4 |          |

Additional funding to for resolving technical and schedule problems.

**Theme:** Solar System Exploration  
**Program:** New Frontiers  
**Project In Development:** New Horizons

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

| <u>New Horizons</u>          | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD             | 140.1         | 103.0         | 87.7          | 16.1          | 9.5           | 5.7           | 6.1           |
| Changes from FY 2005 Request | 23.3          | -12.8         | 3.3           | -2.9          | 1.1           | -0.2          |               |

**Overview**

The New Horizons Pluto mission will conduct a reconnaissance of the Pluto-Charon system and potentially the Kuiper Belt. The mission objectives are to: a) Characterize the global geology and morphology of Pluto and Charon; b) Map the surface composition of Pluto and Charon; and c) Characterize the neutral atmosphere of Pluto and its escape rate.

New Horizons will seek to answer key scientific questions regarding the surfaces, atmospheres, interiors, and space environments of Pluto and Charon using imaging, visible and infrared spectral mapping, ultraviolet spectroscopy, radio science, and in-situ plasma sensors.

The New Horizons Homepage can be accessed at:  
<http://pluto.jhuapl.edu/mission.htm>



New Horizons spacecraft and payload in deep space - artist's conception.

**Changes From FY 2005**

- None.

**Program Management**

The Applied Physics Laboratory is responsible for New Horizons project management.

**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. The spacecraft may then head deeper into the Kuiper Belt to study one or more of the icy mini-worlds in that vast region that lies at least a billion miles beyond Neptune's orbit.

**Theme:** Solar System Exploration  
**Program:** New Frontiers  
**Project In Development:** New Horizons

### Schedule

| Date      | Key Milestones                 | Change From FY 2005 |
|-----------|--------------------------------|---------------------|
| 6/2001    | Approved for Formulation       | None                |
| 3/2003    | Approved for Implementation    | None                |
| 10/2003   | Critical Design Review         | None                |
| 1/2006    | Launch                         | None                |
| 3/2007    | Jupiter Flyby / Gravity Assist | None                |
| 7/ 2015   | Pluto-Charon Encounter         | None                |
| 2017-2020 | Kepler Belt Object Encounters  | None                |

### Strategy For Major Planned Acquisitions

- All major acquisitions are in place.

### Key Participants

- Principal Investigator is at Southwest Research Institute.
- Johns Hopkins University/Applied Physics Laboratory has project management responsibility.

### Risk Management

- RISK: Nuclear launch approval process and schedule, launch vehicle certification schedule, observatory delivery schedule, and overall project cost issue. MITIGATION: NASA Headquarters has chartered the Discovery and New Frontiers Program office at the MSFC to perform an Independent Assessment of the New Horizon's mission with respect to the following: 1)Assess the mission's readiness to support a January 2006 launch date; 2)Assess the Project's ability to deliver the Spacecraft and Instruments that meet the AO based contractual requirements.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC   | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-------|-------|----------|
| FY 2006 PRES BUD          | 154.3 | 140.1  | 103.0  | 87.7   | 16.1   | 9.5    | 5.7    | 6.1    | 72.4  | 594.9 |          |
| Changes                   | 0.0   | 23.3   | -12.8  | 3.3    | -2.9   | 1.1    | -0.2   |        | -42.2 | -24.3 |          |
| FY2005 President's Budget | 154.3 | 116.8  | 115.8  | 84.4   | 19.0   | 8.4    | 5.9    |        | 114.6 | 619.2 |          |

Additional funding to cover launch vehicle cost growth.

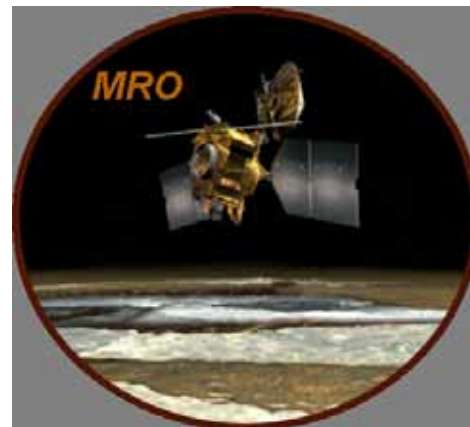
**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Development:** Mars Reconnaissance Orbiter 2005 (MRO)

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

| Mars Reconnaissance Orbiter 2005 (MRO) | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|--|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD                       | 195.3  | 102.7  | 45.5   | 44.0   | 37.2   | 22.9   | 21.6   |
| Changes from FY 2005 Request           | 12.9   | -7.2   | -0.9   | -3.6   | -1.7   | -1.0   |        |

**Overview**

The Mars Reconnaissance Orbiter (MRO) mission objective is to understand the history of water on Mars by observing the planet's atmosphere, surface, and subsurface in unprecedented detail. This mission will identify the best sites for a new generation of landed vehicles to explore, by virtue of its ability to find local evidence of the chemical and geological "fingerprints" of water and other critical processes. MRO will explore from orbit hundreds of locations on the surface of Mars, observing details that were previously only visible to landers. MRO will focus on locations identified as most promising by Mars Global Surveyor and Odyssey, searching for the presence of surface materials conducive to biological activity or having the potential for preserving biogenic materials.



The MRO website can be accessed at:  
<http://mars.jpl.nasa.gov/missions/future/2005-plus.html>

MRO Payload and Spacecraft - artist's conception orbiting MARS.

**Changes From FY 2005**

- None.

**Program Management**

The JPL is responsible for this segment of the Mars Exploration Program.

**Technical Description**

The MRO will be launched in August 2005 by an intermediate-class expendable launch vehicle from Cape Canaveral Air Station, and will enter Mars orbit in 2006. The MRO mission will use its science payload and engineering systems to acquire global mapping, regional survey, and globally distributed targeted observations from a low-altitude, near-polar, mid-afternoon (dayside) Mars primary science orbit (PSO). Currently, the goal is to achieve a near-polar 255x320 km PSO with closest approach to Mars over the planet's south pole. The MRO will observe the planet's surface and atmosphere and explore its upper crust from the PSO during a primary science phase, lasting one Martian year (687 Earth days).

**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Development:** Mars Reconnaissance Orbiter 2005 (MRO)

### Schedule

| Date           | Key Milestones        | Change From FY 2005 |
|----------------|-----------------------|---------------------|
| 3rd Qtr FY05   | Ship to Cape          |                     |
| 4th QTR FY05   | Launch                | None                |
| FY06 - 4th QTR | MARS Orbit Insertion  | None                |
| 4th QTR FY08   | Primary Science Phase | None                |
| 4th QTR FY2010 | Relay Phase           | None                |

### Strategy For Major Planned Acquisitions

- All Major Acquisitions are in place.

### Key Participants

- Lockheed Martin Aerospace - Spacecraft and System Integrator
- BATC - HIRISE Instrument  
Applied Physics Lab. - CRISM Instrument
- The Agenzia Spaziale Italiana (ASI) - Shallow Radar Radar

### Risk Management

- RISK: Additional problems uncovered during environmental testing will put significant pressure on the limited schedule reserve remaining. MITIGATION: Special risk and work-to-go review conducted; increased program-level monitoring of progress, risk tracking and schedule reserve status; evaluating efficiencies in launch site flow.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC   | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-------|-------|----------|
| FY 2006 PRES BUD          | 216.9 | 195.3  | 102.7  | 45.5   | 44.0   | 37.2   | 22.9   | 21.6   |       | 686.0 |          |
| Changes                   | 0.0   | 12.9   | -7.2   | -0.9   | -3.6   | -1.7   | -1.0   |        | -11.8 | 8.3   |          |
| FY2005 President's Budget | 216.9 | 182.4  | 109.9  | 46.4   | 47.6   | 38.9   | 23.9   |        | 11.8  | 677.8 |          |

Additional funding to for resolving technical and schedule problems to meet the August 2005 launch date.

**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Formulation:** Phoenix (Scout 07)

**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>Phoenix (Scout 07)</u>    | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|------------------------------|---------------|---------------|---------------|
| FY 2006 PRES BUD             | 25.4          | 96.1          | 94.4          |
| Changes from FY 2005 Request | -3.5          | -6.7          |               |

**Overview**

The Mars Phoenix overall mission is to uncover clues to the geologic history and biological potential of the Martian arctic. Phoenix will be the first mission to return data from either polar region, providing an important contribution to the Mars science strategy of "follow the water."

While providing investigator-led flexibility to the Mars Program and allowing for reduced total mission life-cycle costs and development time, this project will also enhance public awareness of, and appreciation for, Mars exploration. Educational and public outreach activities are being incorporated as integral parts of Mars science investigations.

The Phoenix mission is the first in a series of smaller, lower-cost, completed spacecraft with the goal of a mission launch approximately every four years. Named for the resilient mythological bird, Phoenix uses a lander that was intended for use by 2001's Mars Surveyor lander prior to its cancellation. It also carries a complex suite of instruments that are improved variations of those that flew on the lost Mars Polar Lander.

For more information on the Phoenix mission, visit:  
<http://phoenix.lpl.arizona.edu>



Phoenix payload and spacecraft on MARS - artist's conception.

**Changes From FY 2005**

- None.

**Program Management**

Phoenix is a Principal Investigator-led Project. Program management responsibility has been delegated to JPL.

**Technical Description**

In the continuing pursuit of water on Mars, the poles are a good place to probe, as water ice is found there. Phoenix will land on the icy northern pole of Mars between 65 and 75-north latitude. During the course of the 150 Martian day mission, Phoenix will deploy its robotic arm and dig trenches up to half a meter (1.6 feet) into the layers of water ice. These layers, thought to be affected by seasonal climate changes, could contain organic compounds that are necessary for life. To analyze soil samples collected by the robotic arm, Phoenix will carry an "oven" and a "portable laboratory." Selected samples will be heated to release volatiles that can be examined for their chemical composition and other characteristics.

**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Formulation:** Phoenix (Scout 07)

### Schedule

| Date        | Key Milestones                    | Change From FY 2005 |
|-------------|-----------------------------------|---------------------|
| Feb 2005    | Phoenix Preliminary Design Review |                     |
| March 2005  | Phoenix Confirmation Review       |                     |
| August 2005 | Phoenix Critical Design Review    |                     |
| Aug, 2007   | Launch Date                       |                     |
| 2008/2009   | Orbit Insertion / End of Mission  |                     |

### Strategy For Major Planned Acquisitions

- All major acquisitions are already in place

### Key Participants

- Principal Investigator - University of Arizona, Lunar and Planetary Laboratory
- Lockheed Martin Aerospace - spacecraft provider



**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Formulation:** 2009 Mars Science Laboratory

**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>2009 Mars Science Laboratory</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|-------------------------------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                    | 111.7         | 162.3         | 183.9         |
| Changes from FY 2005 Request        | -5.6          | -12.3         |               |

**Overview**

The 2009 Mars Science Laboratory (MSL) will be a long-duration, roving science laboratory that will provide a major leap in surface measurement technology focusing on Mars habitability. Detailed measurements will be made of element composition, elemental isotopes and abundance, mineralogy, and organic compounds to determine if Mars has, or ever had, an environment capable of supporting life. The project will develop critical technologies for Entry, Descent, and Landing (EDL), long-life systems, autonomous operations, sample acquisition, handling and processing, and Mars proximity telecommunications.



Some of the key attributes of the 2009 MSL mission include: 12 months of flight time; five to six course corrections; direct entry with altimetry performed in terminal descent; a 450-600 kg rover; 2 earth years lifetime; 10 kilometer mobility.

MSL Rover on Mars - artist's conception.

The MSL Website can be accessed at:  
<http://marsprogram.jpl.nasa.gov/missions/future/msl.html>

**Changes From FY 2005**

- None.

**Program Management**

2009 MSL is a hybrid JPL-Science Community Mission with all major instrument acquisitions in place.

**Technical Description**

MSL is planned for launch in the September-October 2009 time frame, and will arrive at Mars in August 2010. The EDL system will be designed to accommodate a wide range of possible latitude and altitude locations on Mars in order to be discovery-responsive and to have the capability to reach very promising but difficult-to-reach scientific sites.

**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Formulation:** 2009 Mars Science Laboratory

### Schedule

| Date       | Key Milestones              | Change From FY 2005 |
|------------|-----------------------------|---------------------|
| 4th Qtr 05 | Initial Confirmation Review |                     |
| 4th Qtr 06 | Confirmation Review         |                     |
| 3rd Qtr 07 | Critical Design Review      |                     |
| 10/2009    | Launch                      |                     |
| 2012       | End of Mission              |                     |

### Strategy For Major Planned Acquisitions

- 2009 Mars Science Laboratory - Hybrid JPL in-house and industry.
- All other major acquisitions are in place.

### Key Participants

- Goddard Space Flight Center - Primary Analytical Chemistry Instrument - Sample Analysis at Mars (SAM).
- Honeybee Robotics - Robotic Arm Tools
- Malin Space Systems - Cameras

**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Formulation:** 2009 Mars Telecommunications Orbiter

**President's FY 2006 Budget Request**

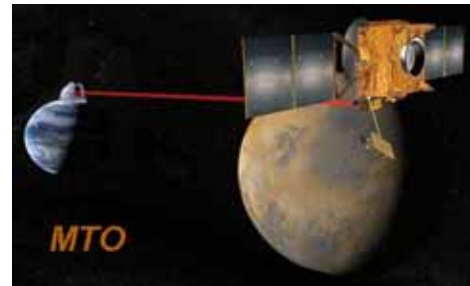
(Dollars in Millions)

| <u>2009 Mars Telecommunications Orbiter</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|---|---------------|---------------|---------------|
| FY 2006 PRES BUD                            | 10.1          | 24.2          | 55.5          |
| Changes from FY 2005 Request                | 0.9           | -0.9          |               |

**Overview**

Mars Telecommunications Orbiter(MTO) will be Mars' first high-speed data connection. The spacecraft will orbit Mars at a higher altitude than most orbiters and provide enhanced data relay for surface missions such as the Mars Science Laboratory.

The spacecraft will communicate with Earth via two radio bands and a new optical communications terminal, which will demonstrate the use of a laser beam for interplanetary communications.



Key attributes of the 2009 U.S. Telecom Orbiter mission: 1-year cruise; 10 years on orbit; Electra UHF and X-band link and gimbled camera. Communications relay for MSL, Scouts, MSR, and Next Decade Mars Surface and orbital Missions. Provide critical event coverage such as Entry Descent Landing (EDL), Mission Orbit Insertion (MOI), or Mars Ascent Vehicle (MAV). Demonstrate deep space laser comm from Mars detect and rendezvous with Orbiting Sample Canister. Demonstrate next generation autonomous navigation.

MTO Payload and Spacecraft orbiting Mars - artist's conception.

**Changes From FY 2005**

- None.

**Program Management**

GSFC is responsible for the Optical Communication Payload.

**Technical Description**

The 2009 MTO will serve as the Mars hub for a growing interplanetary internet. It will use three radio bands (X, Ka, UHF) and will be located at an optimal orbit to maximize coverage of orbital, sub-orbital, and surface assets on Mars. This capability will magnify the benefits of other future Mars missions and enable some types of missions otherwise impractical. The telesat will also include an operational demonstration of optical telecommunications technologies, which will significantly increase the communication data rate and improve the cost per byte of data returned. The Optical Communication Technology Demonstration will be led by the GSFC with the JPL and MIT Lincoln Lab as partners.

**Theme:** Solar System Exploration  
**Program:** Mars Exploration  
**Project In Formulation:** 2009 Mars Telecommunications Orbiter

**Schedule**

| Date                      | Key Milestones                                     | Change From FY 2005 |
|---------------------------|--|---------------------|
| 3rd QTR CY 2005           | MTO Mission & Systems Requirements Review (PreMSR) |                     |
| 2nd QTR CY 05 / 06        | 2009MTO/MLCD PDR-2nd QTR CY05 CDR-2nd QTR CY06     |                     |
| 2nd QTR CY06/2nd QTR CY07 | 2009 MTO PDR -2nd QTR CY06; CDR-2nd QTR CY07       |                     |
| 2nd QTR CY08              | 2009 MTO/MLCD Shipment Review                      |                     |
| 2nd QTR CY08              | 2009 MTO Assembly Readiness Review                 |                     |

**Strategy For Major Planned Acquisitions**

- Spacecraft contractor acquisition is in progress.

**Key Participants**

- Massachusetts Institute of Technology (MIT) /Lincoln laboratories - Optical Communications Package

**Theme:** Solar System Exploration  
**Program:** Robotic Lunar Exploration  
**Project In Formulation:** Lunar Reconnaissance Orbiter (LRO)

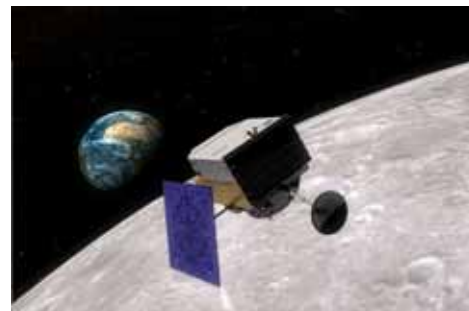
**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>Lunar Reconnaissance Orbiter (LRO)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|---|---------------|---------------|---------------|
| FY 2006 PRES BUD                          | 17.0          | 40.2          | 105.0         |
| Changes from FY 2005 Request              | 17.0          | 40.2          |               |

**Overview**

Lunar reconnaissance Orbiter (LRO) is the first of the Lunar missions. It is planned for launch by late Fall 2008 and will orbit the Moon nominally for one year. The LRO mission emphasizes the objective of advancing Lunar Science and obtaining data that will facilitate returning humans safely to the Moon where testing and preparations for an eventual crewed mission to Mars will be undertaken. Launch of LRO in 2008 is necessary to meet the President's mandate to put humans on the moon between 2015 and 2020.



The following objectives have been defined as having the highest priority to land humans on the moon between 2015-2020:

- \* Characterization of deep space radiation environment in Lunar orbit;
- \* Geodetic global topography;
- \* High spatial resolution hydrogen mapping;
- \* Temperature mapping in polar shadowed regions;
- \* Imaging of surface in permanently shadowed regions;
- \* Identification of putative deposits of appreciable near-surface water ice in polar cold traps;
- \* Assessment of meter and smaller scale features for landing sites; and
- \* Characterization of polar region lighting environment.

Lunar Reconnaissance Orbiter (LRO) spacecraft and payload - Conceptual Design.

The LRO website can be accessed at: <http://lunar.gsfc.nasa.gov/>

**Changes From FY 2005**

- Lunar Reconnaissance Orbiter is a new project in formulation.

**Program Management**

The Robotic Lunar Exploration Program (RLEP) is delegated to the Goddard Space Flight Center (GSFC). Theme responsibility resides at SMD/NASA HQ.

**Theme:** Solar System Exploration  
**Program:** Robotic Lunar Exploration  
**Project In Formulation:** Lunar Reconnaissance Orbiter (LRO)

### Technical Description

The LRO mission will be launched from the NASA Kennedy Space Center Eastern Test Range, on an intermediate-class (e.g., Delta II) launch vehicle with a launch period opening and closing as early as October 2008. Payload instruments will be in a power-off state during the launch and injection phase. The cruise phase begins when the spacecraft separates from the launch vehicle and ends prior to Lunar orbit injection (LOI). The cruise phase lasts approximately a couple days, depending on the launch date, trajectory, and specific orbit selection.

After achieving the final mapping orbit, the LRO baseline mission is nominally one Earth year at a 30-50 kilometer circular, polar orbit. This may be followed by an extended mission of up to five years in a low maintenance orbit.

### Schedule

| Date    | Key Milestones                                | Change From FY 2005 |
|---------|---|---------------------|
| 5/2005  | Mission 2 Announcement of Opportunity Release |                     |
| 6/2005  | LRO Preliminary Design Review                 |                     |
| 10/2005 | Mission 2 Selection                           |                     |
| 12/2005 | LRO Confirmation Review                       |                     |

### Strategy For Major Planned Acquisitions

- The measurement investigations for the LRO were selected through the competitive AO Process.
- Spacecraft - TBD pending RFP release and selection.

### Key Participants

- Instruments selections dependent upon Announcement of Opportunity (AO) down-selection.

**Theme:** The Universe  
**Program:** Navigator  
**Project In Development:** Keck

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

| Keck                         | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 13.2   | 11.3   | 10.4   | 12.6   | 13.0   | 15.4   | 17.0   |
| Changes from FY 2005 Request | 13.2   | 11.3   | 10.4   | 12.6   | 13.0   | 15.4   |        |

**Overview**

The Keck Interferometer (KI) seeks to answer two basic questions: "Where do we come from?" and "Are we alone?" Key to answering these questions is finding out how galaxies, stars and planets form, and whether planets other than Earth have the conditions necessary to support life. To that end, Keck will address six science objectives:

1. MEASURE "EXOZODIACAL" LIGHT AROUND NEARBY STARS: Using a technique called nulling, cancel light from stars to examine the thermal emission from surrounding dust.
2. STUDY "HOT JUPITERS": Characterize atmospheres of hot, Jupiter-mass planets orbiting within 20 million kilometers of their parent stars.
3. FIND PLANETS AROUND NEARBY STARS: Using a technique called astrometry, look for wobble in a star's motion caused by the gravitational influence of an orbiting planet.
4. LOOK FOR NEWBORN STARS: Make images of stars as they emerge from clouds of gas and dust in which they form, and view the disks of gas and dust debris left over after stars have been created, where planets may be forming.
5. VIEW THE FAINTEST AND FARTHEST: Provide detailed information and images of some faint, dim, and distant objects far beyond the Milkyway galaxy.
6. SEE OUR SOLAR SYSTEM FAMILY UP CLOSE: Make very detailed observations of objects within our solar system, including asteroids, comets, and distant outer planets.



Keck Observatory

NASA has proposed adding 4-6 Outrigger Telescopes to the Keck Interferometer to accomplish objectives 3-6, but a final decision as to where to locate the Outriggers is pending the completion of the National Environmental Policy Act process.

For more information, please see:  
[http://planetquest.jpl.nasa.gov/Keck/keck\\_intr](http://planetquest.jpl.nasa.gov/Keck/keck_intr)

**Theme:** The Universe  
**Program:** Navigator  
**Project In Development:** Keck

### Changes From FY 2005

- Nuller is scheduled to become operational in January 2006.
- Nuller Key Project (studying the dust around nearby stars that might be targets for the Terrestrial Planet Finder mission) observations start in early 2006.

### Program Management

JPL is responsible for Keck Interferometer project management. NASA and JPL Program Management Councils have program oversight responsibility.

### Technical Description

KI uses a technique called interferometry to achieve its objectives. Interferometry combines the light from two or more separate telescopes. The image has similar sharpness to that produced by a single telescope whose diameter is as large as the distance between the separate telescopes. The technique also allows measurement of motions of celestial bodies - in this case a star's tiny wobble due to an orbiting planet (Obj 3). This tiny wobble, equivalent to the width of a candy bar on the Moon as seen from Earth, can be measured using just the Outriggers. Obtaining ultra-sharp images (Obj 4-6) requires a large telescope as well, in this case the twin Keck 10-meter telescopes. Objectives 1 and 2 can be accomplished using only the twin Keck telescopes joined as an interferometer.

### Schedule

| Date           | Key Milestones                                    | Change From FY 2005 |
|----------------|---|---------------------|
| April 2001     | "First light" joining twin telescopes (Keck-Keck) | None                |
| April 2004     | Keck-Keck available for general observing         | None                |
| January 2005   | First nulling of star through Keck-Keck           | N/A                 |
| January 2006   | Nulling mode available for key project observing  | N/A                 |
| September 2006 | Differential Phase mode available                 | N/A                 |

### Strategy For Major Planned Acquisitions

- Major acquisitions are already in place.

### Key Participants

- CalTech manages the project, provides technical expertise in interferometry, and develops key hardware and software components. The University of Hawaii holds the lease for the Mauna Kea Science Reserve.
- W.M. Keck Observatory, California Association for Research in Astronomy (CARA) operates the twin Keck 10-meter telescopes, the world's largest. The Keck Observatory manages the subcontract to fabricate the Outrigger Telescopes and will operate the interferometer on Mauna Kea.
- EOS Technologies, Inc., specializes in fabricating telescopes of modest size and is developing the Outrigger Telescopes. Their parent company, EOS, is developing the telescope domes and enclosures.
- SAIC and Tetra Tech support NASA in the Environmental Impact Statement process.



**Theme:** The Universe  
**Program:** Navigator  
**Project In Development:** Keck

**Budget Detail/Life Cycle Cost** (Dollars in Millions)

| Budget Authority                | Prior       | FY2004      | FY2005      | FY2006      | FY2007      | FY2008      | FY2009      | FY2010      | BTC | Total        | Comments |
|---------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-----|--------------|----------|
| FY 2006 PRES<br>BUD             | <u>71.1</u> | <u>13.2</u> | <u>11.3</u> | <u>10.4</u> | <u>12.6</u> | <u>13.0</u> | <u>15.4</u> | <u>17.0</u> |     | <u>163.9</u> |          |
| Changes                         | <u>71.1</u> | <u>13.2</u> | <u>11.3</u> | <u>10.4</u> | <u>12.6</u> | <u>13.0</u> | <u>15.4</u> |             |     | <u>163.9</u> |          |
| FY2005<br>President's<br>Budget |             |             |             |             |             |             |             |             |     |              |          |

**Theme:** The Universe  
**Program:** Navigator  
**Project In Formulation:** Space Interferometry Mission (SIM)

**President's FY 2006 Budget Request**

(Dollars in Millions)

| Space Interferometry Mission (SIM) | FY2004 | FY2005 | FY2006 |
|------------------------------------|--------|--------|--------|
| FY 2006 PRES BUD                   | 87.9   | 145.3  | 109.0  |
| Changes from FY 2005 Request       | 16.5   | -9.8   |        |

**Overview**

Are planetary systems like this solar system common in the universe? In NASA's search for Earth-like planets, the question of where to look is key. Within the Navigator program, the Space Interferometry Mission is charged with the critical task of carrying out a planet census of potential targets for subsequent TPF missions. SIM provides the only method for unambiguously measuring mass, which determines a planet's ability to retain atmosphere long enough to make it possible to harbor.



How large is the universe? How old? What is dark matter and where is it found? In addition to searching for terrestrial planets, the SIM astrophysics program will address a host of other important questions as it maps the structure of this galaxy as well as those nearby.

SIM technology development is nearly complete, with only one of eight milestones remaining before the project is ready for implementation.

Artist's impression of SIM

For more information, please see:  
[http://planetquest.jpl.nasa.gov/SIM/sim\\_index.html](http://planetquest.jpl.nasa.gov/SIM/sim_index.html)

**Changes From FY 2005**

- 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 is responsible for SIM project management. NASA and JPL Program Management Councils have program oversight responsibility.

**Technical Description**

SIM is designed as a space-based 10-meter baseline interferometer operating in the visible wavelength. Launched on an evolved expendable launch vehicle, SIM will enter an Earth-trailing solar orbit to carry out a 5-year operational mission with a 10-year goal.

**Theme:** The Universe  
**Program:** Navigator  
**Project In Formulation:** Space Interferometry Mission (SIM)

### Schedule

| Date | Key Milestones            | Change From FY 2005 |
|------|---------------------------|---------------------|
|      | Schedule is under review. | N/A                 |

### Strategy For Major Planned Acquisitions

- Members of the SIM science team selected through an Announcement of Opportunity. Other government agencies and universities are included in this team.
- A competitive Request For Proposal was issued for spacecraft, Assembly, Test and Launch Operations (ATLO), and operations support and Northrop Grumman Space Technology (NGST) was selected.

### Key Participants

- U.S. Naval Observatory: SIM Science Team member with Memorandum Of Understanding for collaboration and exchange of data sets.
- Universities: SIM science team.
- Northrop Grumman Space Technology: spacecraft, ATLO, and operations support.

**Theme:** The Universe  
**Program:** James Webb Space Telescope  
**Project In Formulation:** James Webb Space Telescope

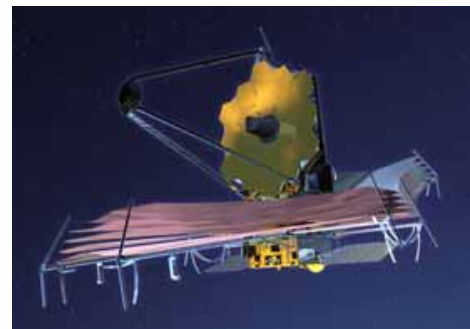
**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>James Webb Space Telescope</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|-----------------------------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                  | 243.2         | 295.3         | 351.6         |
| Changes from FY 2005 Request      | -9.9          | -22.8         |               |

**Overview**

The James Webb Space Telescope (JWST)--identified by the National Research Council as a top priority for astronomy and physics for the 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 Hubble Space Telescope (HST), extending Hubble's discoveries into the infrared, where the highly red-shifted early universe can be observed, where cool objects like protostars and protoplanetary disks emit strongly, and where dust obscures shorter wavelengths.



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. Focus of scientific study will include first light, assembly of galaxies, origins of stars and planetary systems, and origins of life.

Artist's impression of JWST

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

**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°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 thus 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 Earth, around the Sun-Earth Lagrange point 2 (L2), which is ideally-suited for the observatory's mission.

**Theme:** The Universe  
**Program:** James Webb Space Telescope  
**Project In Formulation:** James Webb Space Telescope

### Schedule

| Date           | Key Milestones                      | Change From FY 2005 |
|----------------|-------------------------------------|---------------------|
| May 2006       | Enter Development (begin Phase C/D) | None                |
| December 2006  | Mission Critical Design Review      | None                |
| September 2009 | Mission Operations Review           | None                |
| August 2011    | Launch                              | None                |

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

**Theme:** The Universe  
**Program:** Stratospheric Observatory for Infrared Astronomy (SOFIA)  
**Project In Development:** 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   | 48.3   | 45.7   | 54.1   | 56.1   | 57.0   | 57.2   |
| Changes from FY 2005 Request                             | 12.5   | -4.2   | -2.5   | -2.7   | -2.7   | -2.8   |        |

**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.



Artist's concept of SOFIA in flight with cavity door open and telescope visible.

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. Project is in development, therefore has baselined a life cycle cost commitment.

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

**Changes From FY 2005**

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

**Program Management**

ARC is responsible for SOFIA project management, including mission and science operations. NASA and ARC PMCs have program oversight responsibility.

**Theme:** The Universe  
**Program:** Stratospheric Observatory for Infrared Astronomy (SOFIA)  
**Project In Development:** Stratospheric Observatory for Infrared Astronomy (SOFIA)

### 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.

### Schedule

| Date           | Key Milestones                                    | Change From FY 2005 |
|----------------|---|---------------------|
| August 2006    | Observatory performance testing complete.         | 12 months           |
| August 2006    | Operational Readiness Review                      | 12 months           |
| September 2006 | First Science Flight/Beginning Science Operations | 12 months           |
| March 2006     | Complete Airworthiness Flight Testing             |                     |

### Strategy For Major Planned Acquisitions

- 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

- DLR is providing 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, ops center, and the first five years of operations.
- L3 Communications is USRA's major sub-contractor for aircraft modifications.

### Risk Management

- RISK: Although unlikely, an aircraft accident could occur. MITIGATION: This risk has been mitigated by adherence to NASA's stringent airworthiness and safety standards and processes, while also requiring Federal Aviation Administration (FAA) certification in the development of the modified SOFIA aircraft.
- 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 (i.e. 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:** Stratospheric Observatory for Infrared Astronomy (SOFIA)  
**Project In Development:** Stratospheric Observatory for Infrared Astronomy (SOFIA)

**Budget Detail/Life Cycle Cost** (Dollars in Millions)

| <b>Budget Authority</b>   | <b>Prior</b> | <b>FY2004</b> | <b>FY2005</b> | <b>FY2006</b> | <b>FY2007</b> | <b>FY2008</b> | <b>FY2009</b> | <b>FY2010</b> | <b>BTC</b> | <b>Total</b> | <b>Comments</b> |
|---------------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|------------|--------------|-----------------|
| FY 2006 PRES BUD          | <u>318.0</u> | <u>66.9</u>   | <u>48.3</u>   | <u>45.7</u>   | <u>54.1</u>   | <u>56.1</u>   | <u>57.0</u>   | <u>57.2</u>   |            | <u>703.3</u> |                 |
| Changes                   | <u>0.0</u>   | <u>12.5</u>   | <u>-4.2</u>   | <u>-2.5</u>   | <u>-2.7</u>   | <u>-2.7</u>   | <u>-2.8</u>   |               |            | <u>54.8</u>  |                 |
| FY2005 President's Budget | <u>318.0</u> | <u>54.4</u>   | <u>52.5</u>   | <u>48.2</u>   | <u>56.8</u>   | <u>58.8</u>   | <u>59.8</u>   |               |            | <u>648.5</u> |                 |



**Theme:** The Universe  
**Program:** Gamma-ray Large Area Space Telescope (GLAST)  
**Project In Development:** Gamma-ray Large Area Space Telescope (GLAST)

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

| <u>Gamma-ray Large Area Space Telescope (GLAST)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|---|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                                    | 102.7         | 101.4         | 94.1          | 63.2          | 22.6          | 18.3          | 24.4          |
| Changes from FY 2005 Request                        | -12.3         | -1.8          | -6.6          | -0.4          | -26.8         | -6.0          |               |

**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 impression of GLAST

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/>

**Changes From FY 2005**

- Mission Critical Design Review was delayed due to the rebaseline of the Large Area Telescope (LAT) and withdrawal of international partners.

**Program Management**

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

**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 GLAST Gamma Ray Burst Monitor (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.

**Theme:** The Universe  
**Program:** Gamma-ray Large Area Space Telescope (GLAST)  
**Project In Development:** Gamma-ray Large Area Space Telescope (GLAST)

### Schedule

| Date           | Key Milestones                 | Change From FY 2005 |
|----------------|--------------------------------|---------------------|
| June 2003      | Preliminary Design Review      | None                |
| December 2003  | Non-Advocate Review            | None                |
| September 2004 | Mission Critical Design Review | Delayed 7 months    |
| May 2007       | Launch                         | None                |

### Strategy For Major Planned Acquisitions

- The Science Support Center at GSFC will support guest observers (GO) and manage annual solicitation for GOs. Mission Ops Center personnel at GSFC will be provided by contractor set aside procurement.
- 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.

### Key Participants

- The Naval Research Laboratory, which assembles the Calorimeter for the LAT, environmentally tests the integrated instrument and provides science support.
- Stanford University is the home institution of the principal investigator of the LAT, and is also providing science support.
- 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.
- Large Area Telescope development and instrument integration is managed by the Stanford Linear Accelerator Center, a Department of Energy funded laboratory located at Stanford University.

### 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.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC    | Total  | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----------|
| FY 2006 PRES BUD          | 103.1 | 102.7  | 101.4  | 94.1   | 63.2   | 22.6   | 18.3   | 24.4   |        | 529.9  |          |
| Changes                   | 0.0   | -12.3  | -1.8   | -6.6   | -0.4   | -26.8  | -6.0   |        | -192.6 | -222.0 |          |
| FY2005 President's Budget | 103.1 | 115.0  | 103.2  | 100.7  | 63.6   | 49.4   | 24.3   |        | 192.6  | 751.9  |          |

**Theme:** The Universe  
**Program:** Discovery  
**Project In Formulation:** Kepler

## President's FY 2006 Budget Request

(Dollars in Millions)

| Kepler                       | FY2004 | FY2005 | FY2006 |
|------------------------------|--------|--------|--------|
| FY 2006 PRES BUD             | 50.8   | 118.9  | 111.5  |
| Changes from FY 2005 Request | 0.0    | -8.3   |        |

## Overview

The centuries-old search for other Earth-like worlds has been rejuvenated by the intense excitement and popular interest surrounding the discovery of giant planets like Jupiter orbiting stars beyond our solar system. With the exception of the pulsar planets, all of the extrasolar planets detected so far are gas giants. The challenge now is to find terrestrial planets that are 30 to 600 times less massive than Jupiter. The Kepler mission is specifically designed to survey the extended solar neighborhood to detect and characterize hundreds of terrestrial and larger planets. Transits by terrestrial planets produce a fractional change in stellar brightness lasting 2 to 16 hours. The orbit and size of the planets can be calculated from the period and depth of the transit. From measurements of the period, change in brightness and known stellar type, the planetary size, orbital size and characteristic temperature are determined. From this the question of whether or not the planet is habitable (not necessarily inhabited) can be answered. The Kepler mission's specific objectives include: (1) determine the frequency of terrestrial and larger planets in or near the habitable zones of a wide variety of spectral types of stars; (2) determine the distribution of planet sizes and their orbital semi-major axes (half the longest diameter of the orbit); (3) estimate the frequency and orbital distribution of planets in multiple-stellar systems; and (4) determine the distributions of semi-major axis, albedo, size, mass, and density of short-period giant planets.

Currently in formulation phase; there is no LCC commitment.

For more information please see <http://www.kepler.arc.nasa.gov>

## Changes From FY 2005

- Launch date being reassessed due to schedule concerns.

## Program Management

JPL is responsible for Kepler project management, and Ames Research Center provides the principal investigator.

**Theme:** The Universe  
**Program:** Discovery  
**Project In Formulation:** Kepler

### Technical Description

The Kepler instrument is a 0.95-meter aperture differential photometer with a 105-degree squared field of view. The spacecraft will be launched into an Earth-trailing, heliocentric orbit. Following a 30-day characterization period, Kepler begins acquiring its scientific data by continuously and simultaneously observing over 100,000 target stars. During the first year, terrestrial planets with orbital periods shorter than that of Mercury -- as well as a wide range of larger planets with similar periods -- should be detected. Finally, the anticipated identification of Earth-size planets in the habitable zones of other star systems will begin during the third year. Mission lifetime is four years.

### Schedule

| Date    | Key Milestones              | Change From FY 2005     |
|---------|-----------------------------|-------------------------|
| 12/2001 | Started Formulation         | None                    |
| 10/2004 | Preliminary Design Review   | none                    |
| 4/2005  | Approval for Implementation | Slip from December 2004 |
| TBD     | Critical Design Review      | Change from 8/05        |
| TBD     | Launch                      | Change from 10/07       |
| TBD     | Mission completion          | Change from 9/2012      |

### Strategy For Major Planned Acquisitions

- All major acquisitions are in place.

### Key Participants

- Ames Research Center, principle investigator, Instrument and Ground System Procurement
- The Jet Propulsion Laboratory, Program Management, Systems engineering, and Spacecraft Procurement
- Ball Aerospace and Technology Corporation, Instrument and Spacecraft development, test, and delivery.
- Laboratory for Atmospheric and Space Physics (LASP) at University of Colorado in Boulder is responsible for Mission Operations.

**Theme:** The Universe  
**Program:** Explorer  
**Project In Formulation:** Wide-field Infrared Survey Explorer (WISE)

**President's FY 2006 Budget Request**

(Dollars in Millions)

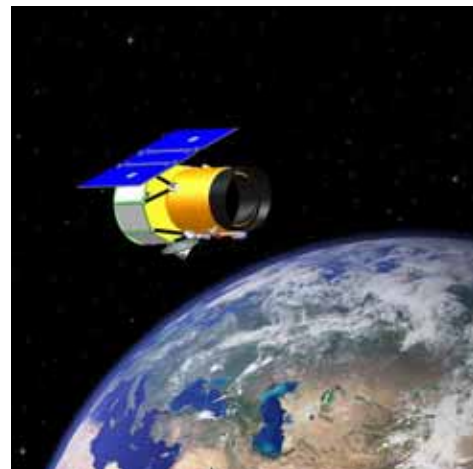
| Wide-field Infrared Survey Explorer (WISE) | FY2004 | FY2005 | FY2006 |
|--|--------|--------|--------|
| FY 2006 PRES BUD                           | 11.4   | 55.0   | 71.9   |
| Changes from FY 2005 Request               | -19.3  | -3.0   |        |

**Overview**

Planned for launch in 2008, WISE will provide a storehouse of knowledge about the solar system, the Milky Way, and the Universe. During its six-month mission, WISE will map the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe. WISE's infrared survey will provide an essential catalog for the James Webb Space Telescope (JWST).

Solar panels will provide WISE with electricity as it orbits several hundred miles above the dividing line between night and day on Earth, looking out at right angles to the Sun and always pointing away from the planet. As the telescope orbits from the North Pole to the equator to the South Pole and then back up to the North Pole, it will sweep out a circle in the sky. As the Earth moves around the Sun, this circle will shift, until WISE has observed the entire sky.

For more information, please visit:  
<http://wise.ssl.berkeley.edu/science.html>



Artist's depiction of WISE satellite in orbit.

**Changes From FY 2005**

- N/A

**Program Management**

JPL is responsible for WISE project management. NASA and JPL Program Management Councils have program oversight responsibility.

**Technical Description**

WISE is a satellite with an infrared-sensitive telescope that will image the entire sky. Since objects near room temperature emit infrared radiation, the telescope and detectors are kept cold (below -430° F/15°K) by a cryostat -- like an ice chest filled with solid hydrogen.

As WISE sweeps the sky, a small mirror will scan in the opposite direction, capturing an image onto an infrared sensitive digital camera every 11 seconds. Each picture will cover an area of the sky 3 times larger than the Moon. After 6 months, WISE will have taken nearly 1,500,000 pictures covering the sky. Data will be downloaded by radio transmission 4 times per day to computers on the ground which will combine the images into an atlas covering the entire celestial sphere, and a list of all the detected objects

**Theme:** The Universe  
**Program:** Explorer  
**Project In Formulation:** Wide-field Infrared Survey Explorer (WISE)

### Schedule

| Date      | Key Milestones            | Change From FY 2005 |
|-----------|---------------------------|---------------------|
| May 2005  | Preliminary Design Review | N/A                 |
| June 2005 | Confirmation Review       | N/A                 |
| July 2005 | Phase C/D Start           | N/A                 |
| June 2008 | Launch                    | N/A                 |

### Strategy For Major Planned Acquisitions

- The cryogenic instrument is being built by Space Dynamics Laboratory; Ball Aerospace and Technologies Corporation is building the spacecraft.

### Key Participants

- UCLA is the lead Principal Investigator; the science team also includes members from Caltech, UC Berkeley, the University of Arizona, and the University of Virginia.

Science operations and data processing will take place at the JPL/Caltech Infrared Processing and Analysis Center.

**Theme:** The Universe  
**Program:** International Space Science Collaboration  
**Project In Development:** Herschel

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

| Herschel                     | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 18.3   | 5.3    | 6.9    | 12.6   | 28.0   | 27.4   | 25.9   |
| Changes from FY 2005 Request | 6.6    | -0.8   | 0.4    | 6.5    | 28.0   | 27.4   |        |

**Overview**

The Herschel Space Observatory will be the first example of a new generation of space telescopes. It will be the first space observatory covering the full far-infrared and sub-millimeter waveband, and its telescope will have the largest mirror ever deployed in space. It will be located 1.5 million kilometers away from Earth at the second Lagrange point of the Earth-Sun system. Herschel will permit high spatial and spectral resolution imaging in the 85-900 micron wavelength region. Superb sensitivity for both photometry and spectroscopy will result from Herschel's high throughput and low thermal background. Herschel's 3.5 meter mirror will collect the light from distant and poorly known objects, such as newborn galaxies thousands of millions of light-years away, and will focus it onto three instruments with detectors kept at temperatures close to absolute zero.



Artist's impression of Herschel observatory.

Herschel will be an infrared telescope used to study: galaxy formation and evolution in the early universe; the nature of active galaxy power sources; star forming regions; and interstellar medium physics in the Milky Way and other galaxies. Herschel will be a multipurpose observatory serving the entire astronomical community. Herschel is led by the European Space Agency (ESA) with NASA providing U.S. participation on two instruments. Project is in development, therefore has baselined a life cycle cost commitment.

For more information, please see: <http://sci.esa.int/science-e/www/area/index.cfm?fareaid=16>

**Changes From FY 2005**

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

**Program Management**

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

**Theme:** The Universe  
**Program:** International Space Science Collaboration  
**Project In Development:** Herschel

### 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 kilometers away from Earth, and a 3.5 meter mirror will collect light from distant and poorly known objects millions of light years away and focus it onto three instruments with detectors kept at temperatures close to absolute zero.

### Schedule

| Date        | Key Milestones | Change From FY 2005 |
|-------------|----------------|---------------------|
| August 2007 | Launch         |                     |

### Strategy For Major Planned Acquisitions

- Herschel is an ESA mission.  
NASA is providing critical components and technologies.

### Key Participants

- Herschel is an ESA mission.  
NASA is providing critical components and technologies to this mission.

### Risk Management

- 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.
- RISK:** Potential launch delay due to ESA spacecraft and instrument schedule issue. **MITIGATION:** NASA will deliver U.S.-developed hardware (instrument components) as soon as flight units have been built and tested.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC   | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-------|-------|----------|
| FY 2006 PRES BUD          | 71.4  | 18.3   | 5.3    | 6.9    | 12.6   | 28.0   | 27.4   | 25.9   | 120.1 | 315.9 |          |
| Changes                   |       | 6.6    | -0.8   | 0.4    | 6.5    | 28.0   | 27.4   |        | 120.1 | 214.1 |          |
| FY2005 President's Budget | 71.4  | 11.7   | 6.1    | 6.5    | 6.1    |        |        |        |       | 101.8 |          |



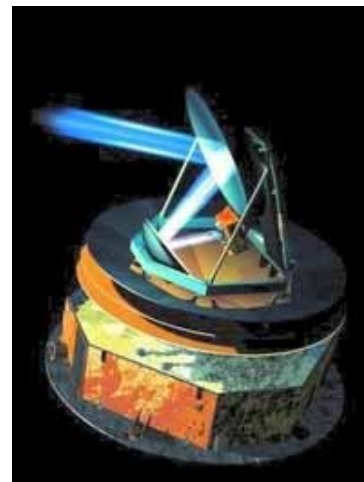
**Theme:** The Universe  
**Program:** International Space Science Collaboration  
**Project In Development:** Planck

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

| Planck                       | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 13.5   | 7.1    | 5.3    | 8.3    | 9.6    | 8.9    | 6.4    |
| Changes from FY 2005 Request | 1.1    | -0.6   | -0.8   | 3.3    | 9.6    | 8.9    |        |

**Overview**

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 researchers observe today as the cosmic microwave background (CMB). Planck will study the global characteristics of the universe (age, composition, topology, etc.) by its precision all-sky measurement of the CMB. Planck is designed to image minor variations in CMB radiation over the whole sky, with unprecedented sensitivity and angular resolution. Planck is led by ESA. NASA participates on the two project instruments.



Artist's impression of Planck observatory.

For more information, please see: <http://sci.esa.int/science-www/area/index.cfm?fareaid=17>.

**Changes From FY 2005**

- In 2004, ESA announced a six-month launch delay which is reflected in the Planck outyear budget.

**Program Management**

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

**Technical Description**

Planck will collect and characterize radiation from the CMB using sensitive radio receivers operating at extremely 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 will produce the best ever maps of anisotropies in CMB radiation field.

**Schedule**

| Date         | Key Milestones | Change From FY 2005 |
|--------------|----------------|---------------------|
| October 2007 | Launch.        |                     |

**Theme:** The Universe  
**Program:** International Space Science Collaboration  
**Project In Development:** Planck

**Strategy For Major Planned Acquisitions**

- Planck is an ESA mission.  
 NASA is providing critical components and technologies to this mission.

**Key Participants**

- Planck is an ESA mission.  
 NASA is providing critical components and technologies to this mission.

**Risk Management**

- RISK:** Potential launch delay due to ESA spacecraft and instrument schedule issue.  
**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.

**Budget Detail/Life Cycle Cost** (Dollars in Millions)

| Budget Authority          | Prior       | FY2004      | FY2005      | FY2006      | FY2007     | FY2008     | FY2009     | FY2010     | BTC         | Total        | Comments |
|---------------------------|-------------|-------------|-------------|-------------|------------|------------|------------|------------|-------------|--------------|----------|
| FY 2006 PRES BUD          | <u>37.7</u> | <u>13.5</u> | <u>7.1</u>  | <u>5.3</u>  | <u>8.3</u> | <u>9.6</u> | <u>8.9</u> | <u>6.4</u> | <u>12.2</u> | <u>109.0</u> |          |
| Changes                   |             | <u>1.1</u>  | <u>-0.6</u> | <u>-0.8</u> | <u>3.3</u> | <u>9.6</u> | <u>8.9</u> |            | <u>12.2</u> | <u>40.1</u>  |          |
| FY2005 President's Budget | <u>37.7</u> | <u>12.4</u> | <u>7.7</u>  | <u>6.1</u>  | <u>5.0</u> |            |            |            |             | <u>68.9</u>  |          |

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Development:** Ocean Surface Topography Mission

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

| Ocean Surface Topography Mission | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD                 | 28.9   | 30.5   | 26.3   | 18.8   | 13.4   | 7.5    | 6.7    |
| Changes from FY 2005 Request     | 28.9   | 30.5   | 26.3   | 18.8   | 13.4   | 7.5    |        |

**Overview**

The Ocean Surface Topography Mission (OSTM) is a cooperative effort between NASA, the National Oceanic and Atmospheric Administration (NOAA), the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), and the Centre National d'Etudes Spatiales (CNES), the space agency of France. OSTM is a follow-on to Jason and will provide continuity of ocean topography measurements beyond Jason and TOPEX/Poseidon. Launch is targeted for FY 2008. OSTM will measure sea surface height to an accuracy of < 4 centimeters every ten days. Sea surface topography, as measured by satellite altimeters, has numerous applications important to global environmental monitoring, including predicting hurricane intensification, improving tide models, mapping deep ocean bathymetry, monitoring, and forecasting El Niño Southern Oscillation, measuring the rate of global sea level rise, and charting surface currents. OSTM supports Objective 14 and APG 6ESS25. Applications of OSTM data will include coastal zone and disaster management.

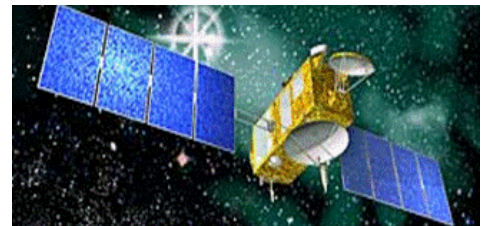


Image of the Ocean Surface Topography Mission (OSTM) spacecraft.

**Changes From FY 2005**

- Replan of Mission Confirmation Review by 8 months to April 2005 and launch to April 2008.

**Program Management**

JPL has project management responsibility. The NASA and JPL Program Management Councils have program oversight responsibility.

**Technical Description**

OSTM will have a three year operational life with a five year goal. It will carry 6 scientific instruments. NASA will provide the Advanced Microwave Radiometer (AMR), the Global Positioning System Payload (GPSP), the Laser Retroreflector Array (LRA), and potentially the optional experimental Wide Swath Ocean Altimeter (WSOA). CNES will provide the Nadir Altimeter and the Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) instruments. The Nadir Altimeter will provide vertical measurements of sea surface height; the AMR will provide atmospheric correction for the Nadir Altimeter; the GPS Payload, LRA, and the DORIS will provide precision orbit determination; and the WSOA will demonstrate new high resolution measurement of ocean surface topography

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Development:** Ocean Surface Topography Mission

### Schedule

| Date   | Key Milestones             | Change From FY 2005 |
|--------|----------------------------|---------------------|
| Apr 05 | Missin Confirmation Review | +8 months           |
| Apr 08 | Launch                     | +8 months           |

### Strategy For Major Planned Acquisitions

- The AMR and WSOA (if option selected) to be built in-house by JPL and GPSP, LRA to be selected by full and open competition.
- The Nadir Altimeter, DORIS and spacecraft to be provided by foreign partner (CNES).
- The launch vehicle to be provided through full and open competition.

### Key Participants

- CNES: Areas of cooperation include spacecraft, instruments, and mission operations.
- EUMETSAT: Areas of cooperation include Earth terminal, data processing, and archiving.
- NOAA: Areas of cooperation include mission operations, data processing, and archiving.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 54.6  | 28.9   | 30.5   | 26.3   | 18.8   | 13.4   | 7.5    | 6.7    | 2.7 | 189.4 |          |
| Changes                   | 54.6  | 28.9   | 30.5   | 26.3   | 18.8   | 13.4   | 7.5    |        | 2.7 | 189.4 |          |
| FY2005 President's Budget |       |        |        |        |        |        |        |        |     |       |          |

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Development:** NPOESS Preparatory Project (NPP)

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

| NPOESS Preparatory Project (NPP) | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD                 | 102.6  | 135.2  | 62.5   | 12.2   | 6.0    | 6.2    | 6.2    |
| Changes from FY 2005 Request     | -0.9   | -5.9   | 0.9    | 5.3    | 6.0    | 6.2    |        |

**Overview**

The NPOESS Preparatory Project (NPP) is a joint mission with NOAA and the U.S. Air Force (USAF) to extend key environmental measurements in support of long-term monitoring of climate trends and global biological productivity. The mission of NPP is two-fold: First, NPP will provide NASA with the continuation of global change observations following the Earth Observing System (EOS) missions Terra and Aqua, specifically, atmospheric and sea surface temperatures, humidity sounding, land and ocean biological productivity, and cloud and aerosol properties. Secondly, NPP will provide the National Polar-orbiting Operational Environmental Satellite System (NPOESS) with risk reduction demonstration and validation for the critical NPOESS sensors, algorithms, and processing. The NPP launch is planned for October 2006 with an operational life of 5 years. NPP supports Objective 14 and AGP 6ESS23.

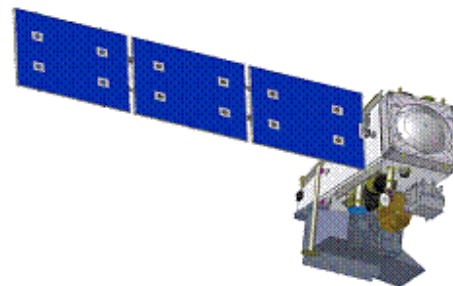


Image of the NPP spacecraft.

For more information see [http://science.hq.nasa.gov/missions/satellite\\_58.htm](http://science.hq.nasa.gov/missions/satellite_58.htm).

**Changes From FY 2005**

- Assumes no changes.

**Program Management**

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

**Technical Description**

The NPP spacecraft will carry four instruments that will provide continuity of imagery, sounding, and ozone mapping and profiling observations for NASA. The satellite will provide regional and global meteorological data as well as oceanographic, environmental and climactic information. The Advanced Technology Microwave Sounder (ATMS) and the Cross-track Infrared Sounder (CrIS) will provide improved measurements of temperature and moisture profiles in the atmosphere. The Visible Infrared Imaging Radiometer Suite (VIIRS) will provide global imagery in a number of visible and infrared frequency bands. The Ozone Mapping and Profiler Suite (OMPS) will collect ozone data in support of the U.S. treaty obligation to monitor the ozone depletion for the Montreal Protocol.

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Development:** NPOESS Preparatory Project (NPP)

### Schedule

| Date   | Key Milestones                  | Change From FY 2005 |
|--------|---------------------------------|---------------------|
| Oct 04 | Spacecraft Integration Complete |                     |
| Apr 05 | ATMS Flight Model Delivery      |                     |
| Sep 05 | OMPS Flight Model Delivery      |                     |
| Oct 05 | CrIS Flight Model Delivery      |                     |
| Nov 05 | VIIRS Flight Model Delivery     |                     |
| Jun 06 | Operational Readiness Review    |                     |
| Oct 06 | Launch                          |                     |

### Strategy For Major Planned Acquisitions

- Not applicable. All procurements for NPP are completed.

### Key Participants

- NPOESS Integrated Program Office (a joint program office inclusive of NASA, NOAA, and USAF): responsible for procuring CrIS, OMPS, VIIRS, ground system, and data processing system.
- NOAA is responsible for providing long-term data archive and storage.

### Risk Management

- **RISK:** 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 major cost increases and a schedule impact of at least 6 months.  
**MITIGATION:** NASA and NOAA/IPO team working together to identify further work-arounds to minimize cost and schedule impacts.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 256.1 | 102.6  | 135.2  | 62.5   | 12.2   | 6.0    | 6.2    | 6.2    |     | 587.1 |          |
| Changes                   | 0.0   | -0.9   | -5.9   | 0.9    | 5.3    | 6.0    | 6.2    |        |     | 17.9  |          |
| FY2005 President's Budget | 256.1 | 103.5  | 141.1  | 61.6   | 6.9    |        |        |        |     | 569.2 |          |

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Global Precipitation Mission

**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>Global Precipitation Mission</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|-------------------------------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                    | 29.2          | 26.3          | 24.0          |
| Changes from FY 2005 Request        | 1.2           | -3.1          |               |

**Overview**

The Global Precipitation Mission (GPM) is a joint mission with the Japan Aerospace Exploration Agency (JAXA) and other international partners. Building upon the success of the Tropical Rainfall Measuring Mission (TRMM), it will initiate the measurement of global precipitation, a key climate factor. Its science objectives are to: improve climate prediction by providing near-global measurement of precipitation, its distribution, and physical processes; improve the accuracy of weather and precipitation forecasts through more accurate measurement of rain rates and latent heating; and provide more frequent and complete sampling of Earth's precipitation. GPM will consist of a core spacecraft to measure precipitation structure and to provide a calibration standard for the constellation spacecraft; an international constellation of NASA and contributed spacecraft to provide frequent precipitation measurements on a global basis; calibration/validation sites distributed globally with a broad array of precipitation-measuring instrumentation, and a global precipitation data system to produce and distribute global rain maps and climate research products. Launches are targeted for FY 2011 and FY 2012. GPM supports Objective 14 and AGP 6ESS22.



Global Precipitation Mission (GPM) constellation.

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

**Changes From FY 2005**

- Assumes NASA purchasing spacecraft from industry through the Rapid Spacecraft Development Office.

**Program Management**

GSFC has project management responsibility. The NASA and GSFC Program Management Councils have program oversight responsibility.

**Technical Description**

The core and constellation spacecraft have a three-year operational life with a five year goal. Other U.S. (POES and NPOESS) and international satellites part of the GPM constellation have similar lifetimes. The core and constellation spacecraft carry three scientific instruments. The Dual-frequency Precipitation Radar (DPR) supplied by JAXA and the GPM Microwave Imagers (GMI) supplied by NASA will fly on the core spacecraft. A GMI will also fly on the NASA constellation spacecraft. The DPR measures the horizontal and vertical structure of rainfall and its microphysics. The GMIs provide additional sampling to improve global rainfall accumulations and extend scientific and societal applications through "calibration" of the other constellation satellites' microwave radiometers.

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Global Precipitation Mission

### Schedule

| Date   | Key Milestones              | Change From FY 2005 |
|--------|-----------------------------|---------------------|
| Jan 06 | Mission Confirmation Review |                     |
| Jun 10 | Launch                      |                     |

### Strategy For Major Planned Acquisitions

- DPR to be provided by foreign partner (JAXA) and GMI to be selected by full and open competition.
- Core spacecraft to be selected by full and open competition. Constellation spacecraft to be selected by full and open competition.
- Launch vehicle to be provided by foreign partner (JAXA).

### Key Participants

- JAXA - Areas of cooperation include DPR, core spacecraft launch, and ground validation.
- European Space Agency/Canadian Space Agency - Areas of cooperation include constellation satellite, instruments, launch, and ground validation.
- CNES - Areas of cooperation include constellation satellite, instruments, launch, and ground validation.



**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Glory

**President's FY 2006 Budget Request**

(Dollars in Millions)

| Glory                        | FY2004 | FY2005 | FY2006 |
|------------------------------|--------|--------|--------|
| FY 2006 PRES BUD             | 12.3   | 54.2   | 5.1    |
| Changes from FY 2005 Request | 0.2    | 0.2    |        |

**Overview**

The Glory mission improves upon NASA's research of forcings that influence climate change in the atmosphere. The scientific knowledge such global satellite observations will provide is essential to predicting climate change and to making sound, scientific based economic and policy decisions related to environmental change. The Glory Aerosol Polarimetry Sensor (APS) is an advanced polarimeter to increase our understanding of black carbon soot and other aerosols as causes of climate change. The APS will provide unprecedented determination of the global distribution of natural and human-made aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the aerosol direct and indirect effects on climate. The solar Total Irradiance Monitor (TIM), a second Glory instrument, provides measurements to maintain an uninterrupted total solar irradiance data record by bridging the gap between NASA's Solar Radiation and Climate Experiment (SORCE) and the National Polar Orbiting Operational Environmental Satellite System (NPOESS) missions. Solar radiation is the dominant, direct energy input into the terrestrial ecosystem, affecting all physical, chemical, and biological processes. These measurements are critical in studies to understand the Sun, its direct and indirect affect on the Earth system, and its influence on humankind. Glory supports Objective 14 and AGP 6ESS25.



Glory Logo

For more on the scientific questions addressed by Glory, visit [www.climatescience.gov](http://www.climatescience.gov).

**Changes From FY 2005**

- Assumes continued build of the APS and TIM instruments; needs flight opportunity

**Program Management**

GSFC has project management responsibility. The NASA and GSFC Program Management Councils have program oversight responsibility.

**Technical Description**

The Glory mission will consist of a two-instrument development effort, the APS and TIM. Flight opportunities for the instruments are under review but are not identified at this time. APS represents the next generation of spaceborne measurement capability by simultaneously providing multispectral and multi-polarization data, as well as along-track multi-angle scanning ability. The Glory APS provides some risk mitigation for the operational instrument planned to fly on the NPOESS mission. The solar TIM is a state-of-the-art radiometer based upon heritage from the successful SORCE instrument.

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Glory

### Schedule

| Date   | Key Milestones              | Change From FY 2005 |
|--------|-----------------------------|---------------------|
| May 05 | Mission Confirmation Review |                     |
| Jan 08 | Instrument Delivery         |                     |

### Strategy For Major Planned Acquisitions

- Not applicable. All procurements for Glory are complete.

### Key Participants

- Columbia University collaborates with the Goddard Institute of Space Studies on APS science requirements, algorithms, and instrument operations, with participation by NOAA/IPO scientists to maximize value to NPOESS.
- University of Colorado provides TIM science and instrument operations expertise.

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Landsat Data Continuity Mission (LDCM)

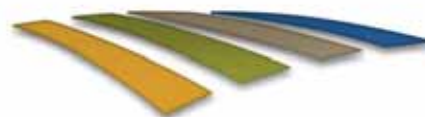
**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>Landsat Data Continuity Mission (LDCM)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|---|---------------|---------------|---------------|
| FY 2006 PRES BUD                              | 35.2          | 38.4          | 54.3          |
| Changes from FY 2005 Request                  | -24.4         | -3.5          |               |

**Overview**

The Landsat Data Continuity Mission (LDCM) is a joint NASA-United States Geological Survey (USGS) mission to extend the Landsat record of multispectral, 30-meter resolution, seasonal, global coverage of the Earth's land surface beyond the Landsat-7 lifetime. LDCM will continue the global land cover data set with provision of synoptic, repetitive multispectral, high-resolution, digital imagery of Earth's land surfaces, and will improve assessment of rates of land-cover changes. NASA and the USGS are working together to ensure the continuity of Landsat data through development of the LDCM system with the assessment of various system development and management options for a satellite system to succeed Landsat 7. Although many options are viable, the partners are focusing on a solution that will satisfy the goals set forth in the Land Remote Sensing Policy Act of 1992 of maintaining "data continuity with the Landsat system," to serve "the civilian, national security, commercial, and foreign policy interests of the United States," and to "incorporate system enhancements... which may potentially yield a system that is less expensive to build and operate and more responsive to users." One of the key objectives of LDCM is to make all Landsat equivalent data collected available at affordable cost. This will enable the many different sectors of the population - farmers, school children, business leaders, scientists, state and federal governments, and many others to continue to utilize this data for high quality research and applications. This program supports Objective 14 and APG 6ESS25.



Landsat Data Continuity Mission (LDCM) logo.

For more information on LDCM, go to:  
[http://science.hq.nasa.gov/missions/satellite\\_56.htm](http://science.hq.nasa.gov/missions/satellite_56.htm)

**Changes From FY 2005**

- Rephasing delivery of the second Operational Land Imager (OLI) Instrument; delivered 2 years after the first OLI delivery to NPOESS.

**Program Management**

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

**Theme:** Earth-Sun System  
**Program:** Earth Systematic Missions  
**Project In Formulation:** Landsat Data Continuity Mission (LDCM)

### Technical Description

LDCM will procure two instruments each with a mission lifetime of 5 years to provide continuity to the Landsat 7 dataset. The LDCM instrument, the OLI will have heritage emphasis on the visible and near-infrared ranges with approximately 9 bands at 30-meter resolution and will enable cross-sensor comparison of any data from within the Landsat series. LDCM will most likely be flown in a sun-synchronous, near-polar orbit, with a mid-morning equatorial crossing time. LDCM data will ensure a minimum of once yearly full global coverage the Earth's complete land mass, coastal boundaries, and coral reefs as well as high-interest shorter repeat cycle phenomenological studies.

### Schedule

| Date   | Key Milestones              | Change From FY 2005 |
|--------|-----------------------------|---------------------|
| Jul 06 | Mission Confirmation Review | New Milestone       |
| Dec 08 | Instrument Delivery         | New Milestone       |

### Strategy For Major Planned Acquisitions

- OLI: To be selected by full and open competition.

### Key Participants

- USGS: areas of cooperation include data management, data distribution, on-orbit calibration and validation, and on-orbit payload operations.
- NOAA: provides spacecraft and instrument integration.

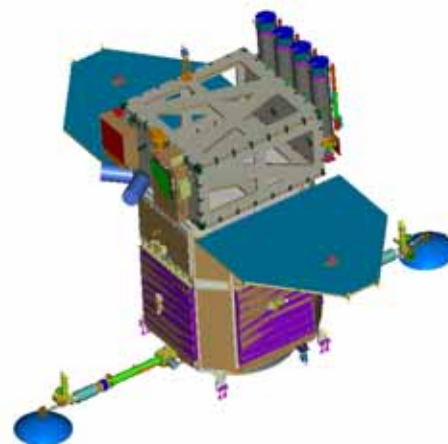
**Theme:** Earth-Sun System  
**Program:** Living with a Star  
**Project In Development:** Solar Dynamics Observatory

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

| Solar Dynamics Observatory   | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 88.1   | 148.4  | 159.2  | 154.1  | 55.0   | 18.6   | 16.1   |
| Changes from FY 2005 Request | 22.3   | -10.0  | 30.3   | 41.4   | 14.1   | -0.5   |        |

**Overview**

The Solar Dynamics Observatory (SDO) is the Living With a Star (LWS) program's first mission. It will investigate how the Sun's magnetic field is structured and how its energy is converted and released into the heliosphere in the forms of solar wind, energetic particles, and variations in solar irradiance. Scientists will analyze data from three instruments, the Helioseismic and Magnetic Imager (HMI), the Extreme Ultraviolet Variability Experiment (EVE), and the Atmospheric Imaging Assembly (AIA), to improve the science needed to enable space weather predictions. The project includes funding for the spacecraft, launch vehicle, data analysis (6 years), project operations (5 years), education, and outreach.



SDO Spacecraft

SDO will explain where and how the Sun's changing magnetic field is generated throughout the solar system. SDO's data set will also become the primary source for U.S. operational space weather activities.

For more information, please see: <http://sdo.gsfc.nasa.gov/>

**Changes From FY 2005**

- Critical Design Review was delayed 2 months due to technical issues; no change to follow-on milestones.

**Program Management**

GSFC is responsible for mission management, design, integration, testing and operation.

**Technical Description**

SDO will be in geosynchronous orbit. It will take data (~130 Mbps), down-link it to a ground station in White Sands, NM, and then forward it to the investigators without processing.

**Schedule**

| Date      | Key Milestones                     | Change From FY 2005 |
|-----------|------------------------------------|---------------------|
| June 2004 | Mission Confirmation Review        | Delayed two months  |
| Apr 2005  | Critical Design Review             | Delayed two months  |
| Jan 2006  | Complete Spacecraft Structure      |                     |
| Feb 2007  | Instrument Delivered to Spacecraft |                     |
| Apr 2008  | Launch                             |                     |

**Theme:** Earth-Sun System  
**Program:** Living with a Star  
**Project In Development:** Solar Dynamics Observatory

### Strategy For Major Planned Acquisitions

- HMI instrument purchased through Stanford University via Announcement of Opportunity competitive selection.
- EVE instrument purchased through the University of Colorado.
- AIA instrument purchased through Lockheed Martin via sole source justification (replaced SHARPP instrument with Naval Research Laboratory).

### Key Participants

- Lockheed Martin Missiles and Space Advanced Technology Center providing AIA instrument.
- Stanford University providing the HMI instrument.
- LASP at University of Colorado providing the EVE instrument.

### Risk Management

- **RISK:** Late addition of a secondary payload could invalidate analyses and test results and cause interface design rework and rebuild. **MITIGATION:** The SDO program may identify secondary payload/launch vehicle schedule and technical requirements and provide them to KSC.
- **RISK:** Problems with the Field Programmable Gate Array (FPGA) may be uncovered after Engineering Test Unit (ETU) build is complete. **MITIGATION:** The SDO program may work with FPGA applications experts to use best information and recommendations for FPGA use.
- **RISK:** The imposition of more stringent security requirements late in the development cycle could cause redesign and rework. **MITIGATION:** The SDO program may allocate resources to thoroughly understand impacts from proposed new security requirements.
- **RISK:** There may be increased procurement costs due to reductions in the spacecraft market. **MITIGATION:** The SDO program may work with industry to understand cost and competition drivers and modify requirements, where appropriate.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC   | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-------|-------|----------|
| FY 2006 PRES BUD          | 67.7  | 88.1   | 148.4  | 159.2  | 154.1  | 55.0   | 18.6   | 16.1   |       | 707.3 |          |
| Changes                   | 0.0   | 22.3   | -10.0  | 30.3   | 41.4   | 14.1   | -0.5   |        | -52.6 | 61.3  |          |
| FY2005 President's Budget | 67.7  | 65.8   | 158.4  | 128.9  | 112.7  | 40.9   | 19.1   |        | 52.6  | 646.1 |          |

The FY 06 increase for SDO reflects the baseline budget requirements. Funding was transferred from within the LWS program to support this increase.

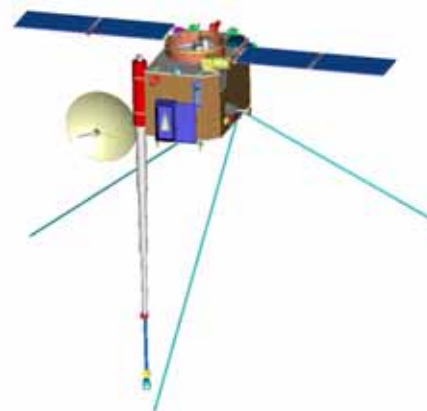
**Theme:** Earth-Sun System  
**Program:** Solar Terrestrial Probes  
**Project In Development:** Solar Terrestrial Relations Observatory (STEREO)

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

| Solar Terrestrial Relations Observatory (STEREO) | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|--|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD                                 | 123.2  | 69.0   | 47.7   | 19.2   | 14.3   | 9.9    | 10.0   |
| Changes from FY 2005 Request                     | 24.5   | -4.8   | 15.1   | -0.1   | 2.0    | 7.0    |        |

**Overview**

The STEREO project will lead to an understanding of the cause and consequences of coronal mass ejections (CME) by: tracing the flow of CMEs from the Sun to Earth; discovering the mechanisms and sites of energetic particle acceleration in the Sun's corona and the interplanetary medium; and developing a three-dimensional time-dependent model of the ambient solar wind. STEREO will also continuously transmit data that will be used to predict space weather. STEREO will use two identically equipped spacecraft in heliocentric orbits, with one leading Earth and the other lagging Earth. Investigations for STEREO will include: Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI), a remote sensing package which will study the three-dimensional evolution of CMEs from the Sun's surface to their eventual impact at Earth; STEREO/WAVES (SWAVES), an interplanetary radio burst tracker that will trace traveling radio disturbances from the Sun to Earth; In situ Measurements of Particles and CME Transients (IMPACT) investigation, which will sample the three-dimensional distribution of solar wind plasma, characteristics of solar energetic particles, and the local vector magnetic field; and the PLAsma and SupraThermal Ion and Composition (PLASTIC) experiment, which will study coronal-solar wind and solar-wind heliospheric processes. Project supports annual performance goals 6ESS8 and 6ESS16.



STEREO Spacecraft

For more information, please see <http://stp.gsfc.nasa.gov/missions/stereo/stereo.htm>

**Changes From FY 2005**

- Increase in spacecraft and instrument costs due to technical and associated schedule issues. Rephase expendable launch vehicle payment.

**Program Management**

STEREO is the third mission within the STP program, with program and project responsibility delegated to Goddard Space Flight Center.

**Technical Description**

The mission design life shall be at least two years for each spacecraft. Assuming a CME rate consistent with minimum of solar magnetic activity cycle, STEREO will observe at least 60 CMEs with remote sensing instruments and at least 24 interplanetary events in situ. STEREO will have two major science instrument suites and two science instruments. The Applied Physics Laboratory will provide mission operations.

**Theme:** Earth-Sun System  
**Program:** Solar Terrestrial Probes  
**Project In Development:** Solar Terrestrial Relations Observatory (STEREO)

### Schedule

| Date      | Key Milestones                                    | Change From FY 2005               |
|-----------|---|-----------------------------------|
| May 2001  | Start of Formulation                              |                                   |
| Mar 2002  | Start of Implementation                           |                                   |
| Feb 2003  | Mission Critical Design Review                    |                                   |
| Sept 2004 | Complete Spacecraft integration & testing (I & T) | Technical issues delayed 4 months |
| June 2005 | Complete Observatory Spacecraft I & T             | Technical issues delayed 5 months |
| Nov 2005  | Launch  | Technical issues delayed 3 months |

### Strategy For Major Planned Acquisitions

- Major acquisitions complete.

### Key Participants

- APL will provide the spacecraft, observatory integration, testing and mission operations.
- NRL will provide the SECCHI remote sensing instrument suites.
- The United Kingdom will provide two Heliospheric Imager instruments.

### Risk Management

- RISK:** It is highly likely that there will be degradation of observatory mass margin.  
**MITIGATION:** The program will perform a series of instrument and spacecraft mass estimate scrubs to verify confidence in remaining estimate margins, and will lighten remaining spacecraft subsystem hardware if possible. The program will consider adjusting the launch window and/or mission design to exercise mass saving options, as required.
- RISK:** The IMPACT Solar Energetic Particles Development schedule may erode due to technical problems.  
**MITIGATION:** The program will prioritize schedule for the mechanical development, and will provide additional questions and answers, engineering and management support to the IMPACT team.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 164.9 | 123.2  | 69.0   | 47.7   | 19.2   | 14.3   | 9.9    | 10.0   |     | 458.1 |          |
| Changes                   | 0.0   | 24.5   | -4.8   | 15.1   | -0.1   | 2.0    | 7.0    |        |     | 53.7  |          |
| FY2005 President's Budget | 164.9 | 98.7   | 73.8   | 32.6   | 19.3   | 12.3   | 2.9    |        |     | 404.5 |          |

STEREO cost increase reflects schedule slip of launch date by three months, instruments increases due to technical problems with the instruments and schedule delay with spacecraft provider. The increase was accommodated within the Solar Terrestrial Program.



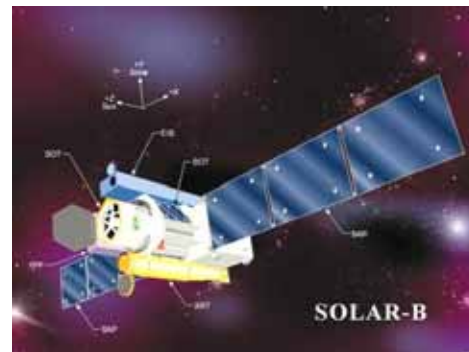
**Theme:** Earth-Sun System  
**Program:** Solar Terrestrial Probes  
**Project In Development:** Solar-B

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

| Solar-B                      | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 16.8   | 11.4   | 14.3   | 14.7   | 12.5   | 12.5   | 10.1   |
| Changes from FY 2005 Request | 4.4    | -0.8   | 3.0    | 14.7   | 12.5   | 12.5   |        |

**Overview**

The Solar-B mission is the second mission in the STP program. Solar-B is an international collaboration building on the highly successful Japan/U.S./UK Yohkoh (Solar-A) project. Solar-B is expected to launch in September 2006 into a sun-synchronous low Earth orbit. It will measure the Sun's magnetic field and ultraviolet/X-ray radiation and use the data to increase the understanding of the sources of solar variability. Solar-B will specifically study the interaction between the Sun's magnetic field and its high-temperature, ionized atmosphere. The result will be an improved understanding of the mechanisms that give rise to solar magnetic variability and how this variability modulates the total solar output and creates the driving force behind space weather. The U.S. responsibility is to manage development of three science instrument components: the Focal Plane Package (FPP), the X-Ray Telescope (XRT), and the Extreme Ultraviolet (EUV) Imaging Spectrometer (EIS).



Solar-B Spacecraft

For more information, please see:  
<http://stp.gsfc.nasa.gov/missions/solar-b/solar-b.htm>

**Changes From FY 2005**

- No changes.

**Program Management**

The Solar-B project is within the STP program, with program management responsibility delegated to GSFC. Solar-B project management is at MSFC.

**Technical Description**

The FPP will be designed to operate in conjunction with the JAXA-provided 0.5 meter solar optical telescope; the XRT will accommodate the JAXA-provided camera and the EIS elements will be designed and constructed to be integral to the United Kingdom-provided EIS instrument. Mission design life is three years.

**Schedule**

| Date      | Key Milestones | Change From FY 2005 |
|-----------|----------------|---------------------|
| Sept 2006 | Solar-B Launch | None                |

**Strategy For Major Planned Acquisitions**

- None

**Theme:** Earth-Sun System  
**Program:** Solar Terrestrial Probes  
**Project In Development:** Solar-B

### Key Participants

- Lockheed Martin Missiles and Space will provide the focal plane package.
- The Smithsonian Astrophysical Observatory will provide x-ray telescope.
- The Naval Research Laboratory will provide the EUV Imaging Spectrograph.
- JAXA will provide spacecraft, launch vehicle, major elements of each scientific instrument, observatory integration and testing, and mission operations.

### Risk Management

- **RISK:** Delays in partner testing and/or launch schedule would impact overall project schedule and cost. **MITIGATION:** The program will continue to negotiate schedules with Japan and will prioritize future budgets to determine any necessary reductions in project support to accommodate possible cost increases.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 82.1  | 16.8   | 11.4   | 14.3   | 14.7   | 12.5   | 12.5   | 10.1   |     | 174.3 |          |
| Changes                   |       | 4.4    | -0.8   | 3.0    | 14.7   | 12.5   | 12.5   |        |     | 56.3  |          |
| FY2005 President's Budget | 82.1  | 12.4   | 12.2   | 11.3   |        |        |        |        |     | 118.0 |          |

**Theme:** Earth-Sun System  
**Program:** Explorer Program  
**Project In Development:** Aeronomy of Ice in the Mesosphere (AIM)

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

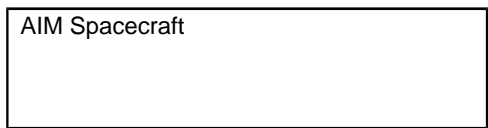
| Aeronomy of Ice in the Mesosphere (AIM) | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|---|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD                        | 21.9   | 30.1   | 27.3   | 6.0    | 3.9    | 3.0    | 3.0    |
| Changes from FY 2005 Request            | -17.9  | -2.1   | 15.0   | 5.3    | 3.9    | 3.0    |        |

**Overview**

AIM will 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. Recorded sightings of these "night-shining," or noctilucent clouds, began in the late 1800s and have increased in frequency. The clouds have also extended to lower latitudes over the past four decades. Scientists have hypothesized that these changes may be related to changes in atmospheric trace gas concentrations and the temperatures they produce. Similar thin high altitude clouds have been observed on Mars. The information AIM provides about Earth's noctilucent clouds should help scientists understand the similarities and differences between the atmospheres of Mars and Earth.



AIM's three instruments, the Cloud Imaging and Particle Size (CIPS), Solar Occultation for Ice Experiment (SOFIE), and the Cosmic Dust Experiment (CDE), will measure all of the parameters important to understanding noctilucent cloud formation, which will help scientists determine the connection between the clouds and their environment and will serve as a baseline for the study of long-term changes in the upper atmosphere. Project supports annual performance goals 6ESS13.



For more information, please see:  
<http://aim.hamptonu.edu/>

**Changes From FY 2005**

- Confirmed to proceed into development in April 2004.

**Program Management**

AIM is a NASA Small Explorer (SMEX) spacecraft with management responsibility delegated to Goddard Space Flight Center.

**Technical Description**

AIM is a SMEX-class mission that will be launched from Vandenberg Air Force Base on a Pegasus XL launch vehicle on September 2006. The spacecraft, developed by Orbital, will be launched into a sun-synchronous orbit of 600 kilometers. Three instruments, CIPS, SOFIE and CDE, will each perform unique stand-alone measurements. The baseline mission duration is 24 months.

**Theme:** Earth-Sun System  
**Program:** Explorer Program  
**Project In Development:** Aeronomy of Ice in the Mesosphere (AIM)

### Schedule

| Date     | Key Milestones          | Change From FY 2005 |
|----------|-------------------------|---------------------|
| Apr 2004 | AIM Confirmation Review | delayed one month   |
| Mar 2005 | Spacecraft I&T Begins   |                     |
| Oct 2005 | Observatory I&T Begins  |                     |
| Sep 2006 | Launch                  |                     |

### Strategy For Major Planned Acquisitions

- AIM is a principal investigator (PI)-led mission. The PI, at Hampton University's Center for Astropheric Science, leads the science, instrument, and spacecraft teams.

### Key Participants

- Hampton University - Principal Investigator
- Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado provides project management, instruments (CIPS, CDE and SOFIE), and mission operations (subcontracted to Hampton University).
- Orbital Science Corp (a subcontractor to LASP) provides the spacecraft bus and will provide observatory integration and testing.

### Risk Management

- RISK:** The replacement of Actel field programmable gate arrays may impact schedule.  
**MITIGATION:** If necessary the project will "borrow" sufficient parts from another project to permit instrument replacement to proceed without schedule impact to fabrication.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 21.1  | 21.9   | 30.1   | 27.3   | 6.0    | 3.9    | 3.0    | 3.0    |     | 116.3 |          |
| Changes                   | 0.0   | -17.9  | -2.1   | 15.0   | 5.3    | 3.9    | 3.0    |        |     | 10.2  |          |
| FY2005 President's Budget | 21.1  | 39.8   | 32.2   | 12.3   | 0.7    |        |        |        |     | 106.1 |          |

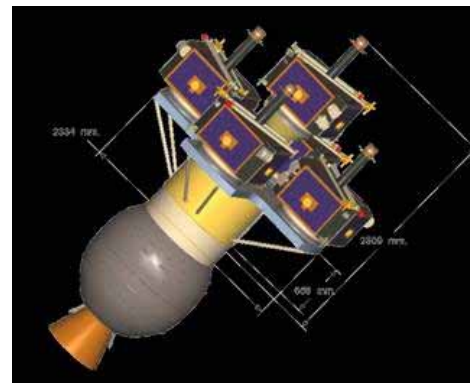
**Theme:** Earth-Sun System  
**Program:** Explorer Program  
**Project In Development:** Thermal Emission Imaging System (THEMIS)

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

| Thermal Emission Imaging System (THEMIS) | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|--|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD                         | 68.8   | 51.6   | 38.8   | 11.8   | 6.3    | 4.0    | 4.0    |
| Changes from FY 2005 Request             | 68.8   | 51.6   | 38.8   | 11.8   | 6.3    | 4.0    |        |

**Overview**

The THEMIS project will lead to the understanding of the onset and evolution of magnetospheric substorms. NASA's THEMIS mission will use five identical microspacecraft (probes) to answer fundamental outstanding questions regarding magnetospheric substorm instability, a dominant mechanism of transport and explosive release of solar wind energy within Geospace. THEMIS will also employ a dense network of ground observatories to time well known plasma particles and fields signatures in Earth's magnetotail, relative to substorm onset. In addition to addressing its primary objective, THEMIS answers critical questions in radiation belt physics and solar wind-magnetosphere energy coupling.



For more information, please see:  
[http://sprg.ssl.berkeley.edu/themis/Flash/THEMIS\\_flash.htm](http://sprg.ssl.berkeley.edu/themis/Flash/THEMIS_flash.htm)

THEMIS Spacecraft

**Changes From FY 2005**

- THEMIS was confirmed to proceed into development in April 2004.

**Program Management**

THEMIS is a NASA Medium-class Explorer (MIDEX) mission, with project responsibility delegated to the Goddard Space Flight Center.

**Technical Description**

THEMIS is Medium-Class Explorer (MIDEX) mission that will be launched from Cape Canaveral, Florida, on a Delta II in October 2006. THEMIS consists of 5 identical probes. There are five instruments on each probe: fluxgate magnetometer (FGM), search coil magnetometer (SCM), electric field instrument (EFI), electrostatic analyzer (ESA) and solid state telescope (SST).

**Theme:** Earth-Sun System  
**Program:** Explorer Program  
**Project In Development:** Thermal Emission Imaging System (THEMIS)

### Schedule

| Date      | Key Milestones                             | Change From FY 2005 |
|-----------|--|---------------------|
| Apr 2004  | THEMIS Confirmed                           | Baseline Schedule   |
| Mar 2005  | Instrument I&T Begins                      |                     |
| July 2005 | Spacecraft Integration and Testing Begins  |                     |
| Mar 2006  | Observatory Integration and Testing Begins |                     |
| Oct 2006  | Launch                                     |                     |

### Strategy For Major Planned Acquisitions

- UCB will provide the 3 instruments and the mission and science operations.
- Swales Aerospace will provide the spacecraft, integration and test, spacecraft carrier, launch vehicle integration, and launch support to UCB.

### Key Participants

- University of California at Berkeley - Principal Investigator.
- Swales Aerospace Corporation is providing the spacecraft bus.
- International Instruments: France - SCM; Germany - FGM.

### Risk Management

- RISK: The baseline design for probe release mechanism fails to meet mission requirements, necessitating a redesign. This activity may impact schedule reserves. MITIGATION: The project will develop an engineering test unit to support early testing.
- RISK: Orbital debris analysis (ODA) of the launch vehicle (Delta II second and third stages) indicates non-compliance with orbital debris guideline. Subsequent changes in the orbital design may impact science.  
 MITIGATION: the project will meet with NASA Headquarters' Science Mission Directorate and Safety Office to discuss ODA non-compliance.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 12.1  | 68.8   | 51.6   | 38.8   | 11.8   | 6.3    | 4.0    | 4.0    |     | 197.4 |          |
| Changes                   | 12.1  | 68.8   | 51.6   | 38.8   | 11.8   | 6.3    | 4.0    |        |     | 197.4 |          |
| FY2005 President's Budget |       |        |        |        |        |        |        |        |     |       |          |

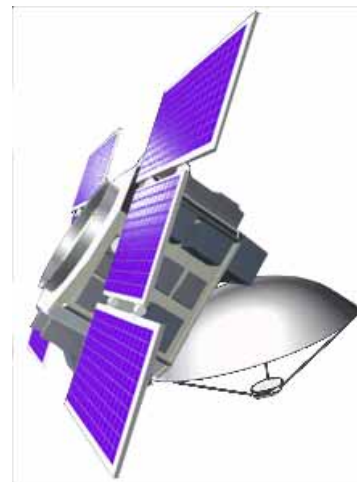
**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Cloudsat

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

| Cloudsat                     | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 29.2   | 8.0    | 4.8    | 1.3    |        |        |        |
| Changes from FY 2005 Request | 12.8   | 4.9    | 3.4    | 1.3    |        |        |        |

**Overview**

CloudSat observations will improve cloud modeling, contributing to better predictions of cloud formation and distribution and to a better understanding of the role of clouds in Earth's climate system. Clouds are the key component of Earth's hydrological cycle, and they dominate the planet's solar and thermal radiation budgets. Even small changes in their abundance or distribution could significantly alter the climate. These considerations lead scientists to believe that the main uncertainties in climate model simulations are due to the difficulties in adequately representing clouds and their radiative properties. CloudSat will fly a millimeter-wave (94 GHz) radar that is capable of seeing a large fraction of clouds and precipitation, from very-thin cirrus clouds to thunderstorms producing heavy precipitation. CloudSat will furnish data needed to evaluate and improve the way clouds are represented in global models, thereby contributing to better predictions of clouds and a more complete knowledge of their role in climate change. CloudSat, a collaboration among NASA, the Canadian Space Agency (CSA), and the U.S. Air Force (USAF), is co-manifested with CALIPSO for launch aboard a Boeing Delta II rocket. The mission will fly in formation with CALIPSO and as part of a larger constellation with Aura and Aqua and the French satellite, Parosol. This project supports Objective 14 and Agency Performance Goal 6ESS25.



CloudSat has a nadir pointing radar optimized to penetrate clouds and reveal their interior water and aerosol content.

For more information see <http://CloudSat.atmos.colostate.edu/>

**Changes From FY 2005**

- Mission requirements replanned. Launch delay of 2 months to May 2005.

**Program Management**

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



**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Cloudsat

### Technical Description

The single CloudSat instrument is the Cloud Profiling Radar (CPR). The CPR is a 94-GHz nadir-looking radar that measures the power backscattered by clouds as a function of distance from the radar. CloudSat will be co-manifested with CALIPSO on a Delta II launch vehicle. CloudSat will fly in formation with CALIPSO as part of the "A-Train" constellation. The CloudSat CPR provides calibrated, range-resolved radar reflectivity measurements. The USAF will provide ground operations and manage communications to the satellite. The data will be routed through the Air Force facility at Kirtland Air Force Base to the Colorado State University Cooperative Institute for Research in the Atmosphere (CIRA). CIRA will be responsible for processing, archiving and distributing the mission science data.

### Schedule

| Date   | Key Milestones                                    | Change From FY 2005 |
|--------|---|---------------------|
| Jul 04 | Instrument delivery to S/C to start satellite AIT |                     |
| Jan 05 | Satellite environmental tests complete            |                     |
| Mar 05 | Delivery to Launch Site                           |                     |
| May 05 | Launch  | +2 months           |
| May 06 | First data products delivered                     | +2 months           |
| Mar 07 | End of primary mission                            | +2 months           |

### Strategy For Major Planned Acquisitions

- None remaining.

### Key Participants

- Colorado State University: provides Principal Investigator and data processing
- JPL: provides instrument development, integration, and test
- CSA: provides CPR key element; USAF: provides ground stations for mission operations
- DoE: provides early mission calibration and validation phase expertise

### Risk Management

- RISK:** 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 to make optimum use of the instrument synergy of the different A-Train satellites. **MITIGATION:** NASA established the A-Train constellation working group, made up 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.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 119.3 | 29.2   | 8.0    | 4.8    | 1.3    |        |        |        |     | 162.6 |          |
| Changes                   | 0.0   | 12.8   | 4.9    | 3.4    | 1.3    |        |        |        |     | 22.5  |          |
| FY2005 President's Budget | 119.3 | 16.4   | 3.1    | 1.4    |        |        |        |        |     | 140.2 |          |



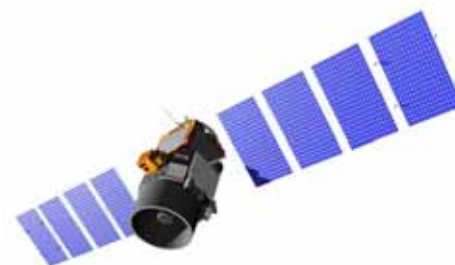
**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

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

| Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|--|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD   | 40.8   | 14.5   | 3.5    | 4.7    | 2.8    |        |        |
| Changes from FY 2005 Request   | 12.6   | 4.4    | -0.2   | 2.1    | 2.7    | -0.1   |        |

**Overview**

CALIPSO mission will address the role of clouds and aerosols in Earth's atmosphere, providing key measurements to improve knowledge of their three, dimensional distribution, radiative properties, and effect on Earth's climate. The mission will fly a 3-channel lidar (a laser) in formation with CloudSat and in a constellation with Aura and Aqua to obtain coincident observations of radiative fluxes and the atmosphere. This set of measurements is essential for quantification of global aerosol and cloud radiative effects. CALIPSO consists of a partnership between NASA and France's Centre Nationale D'Etudes Spatiale (CNES). CNES is providing a Proteus spacecraft, the imaging infrared radiometer (IIR), integrated observatory integration and test, and spacecraft mission operations. Together, CALIPSO and Aqua provide: (1) a global measurement suite from which the first observationally based estimates of aerosol direct radiative forcing of climate can be made; (2) a dramatically improved empirical basis for assessing aerosol indirect radiative forcing of climate; (3) a factor of 2 improvement in the accuracy of satellite estimates of long-wave radiative fluxes at Earth's surface and in the atmosphere; and (4) a new ability to assess cloud-radiation feedback in the climate system. CALIPSO is co-manifested with CloudSat and scheduled to launch no earlier than May 2005. This project supports Objective 14 and Agency Performance Goal 6ESS25.



The CALIPSO satellite will provide data key to understanding the role of clouds and aerosols in Earth's radiation budget, providing key measurements to improve climate predictions.

For more information see <http://www-calipso.larc.nasa.go>

**Changes From FY 2005**

- Mission requirements replanned. Launch delay of 2 months to May 2005.

**Program Management**

GSFC has project management responsibility. The NASA and joint LaRC/GSFC Program Management Councils have program oversight responsibility.

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Development:** Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)

### Technical Description

CALIPSO carries three science instruments: a three-channel LIDAR, and IIR, and a wide field camera (WFC). The LIDAR and WFC are provided by NASA and the IIR by CNES. CALIPSO will launch with CloudSat on a Delta II launch vehicle into 705 kilometer altitude, 98.08° inclined orbit, and will fly in formation with CloudSat and in a larger constellation with Aura, Aqua, and Parosol. The science data sets produced by CALIPSO will include aerosol and cloud vertical distributions, aerosol extinction and optical depth, optical depth, emissivity, and effective particle size content of clouds and cloud surface atmospheric radiative fluxes. The Mission Operations Control Center will be at LaRC and the Satellite Operations Control Center at CNES facilities in Toulouse, France

### Schedule

| Date   | Key Milestones                                     | Change From FY 2005 |
|--------|--|---------------------|
| Mar 04 | Payload (all 3 instruments) delivery to spacecraft |                     |
| Apr 05 | Satellite delivery to launch site                  |                     |
| May 05 | Launch   | +2 months           |
| Nov 06 | 1st calibrated & validated data products delivered | +2 months           |
| May 08 | End of primary mission                             | +2 months           |

### Strategy For Major Planned Acquisitions

- N/A, all procurements for CALIPSO are completed

### Key Participants

- GSFC - Provides project and program management
- LaRC - Provides principle investigator and primary instrument (LIDAR)
- CNES - Provides spacecraft, system level integration and testing, and satellite ground station and mission control

### Risk Management

- RISK: If formation flying with CloudSat and the insertion into the A-Train can not 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 to make optimum use of the instrument synergy of the different A-Train satellites. MITIGATION: NASA established the A-Train constellation working group, made up 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.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 118.5 | 40.8   | 14.5   | 3.5    | 4.7    | 2.8    |        |        |     | 184.7 |          |
| Changes                   | 0.0   | 12.6   | 4.4    | -0.2   | 2.1    | 2.7    | -0.1   |        |     | 21.5  |          |
| FY2005 President's Budget | 118.5 | 28.2   | 10.1   | 3.7    | 2.6    | 0.1    | 0.1    |        |     | 163.3 |          |

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Formulation:** Orbiting Carbon Observatory

**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>Orbiting Carbon Observatory</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|------------------------------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                   | 18.9          | 37.5          | 46.9          |
| Changes from FY 2005 Request       | 1.3           | -7.9          |               |

**Overview**

The Orbiting Carbon Observatory (OCO) mission is part of ESSP in the NASA Science Mission Directorate. OCO was competitively selected from proposals submitted in response to ESSP Announcement of Opportunity 3. OCO will make the first space-based measurements of atmospheric carbon dioxide (CO<sub>2</sub>) with the precision, resolution, and coverage needed to characterize its sources and sinks on regional scales and quantify their variability over the seasonal cycle. The data received from OCO will provide an improved understanding of CO<sub>2</sub> sinks, a critical element in making more reliable climate predictions. OCO will help address two important Earth science questions: 1) What human and natural processes are controlling atmospheric CO<sub>2</sub>; and 2) What are the relative roles of the oceans and land ecosystems in absorbing CO<sub>2</sub>? This project supports Objective 14 and APG 6ESS25.



Image of the Orbiting Carbon Observatory (OCO) Spacecraft

For more information, please see [http://sciencedev.hq.nasa.gov/missions/satellite\\_61.htm](http://sciencedev.hq.nasa.gov/missions/satellite_61.htm).

**Changes From FY 2005**

- OCO schedule rephased.

**Program Management**

OCO is led by a PI from the JPL. Project management and the Program Management Council responsibility also reside at JPL.

**Technical Description**

During its two-year mission, OCO will fly in a Sun-synchronous polar orbit that provides near-global coverage of the sunlit portion of Earth, with a 16-day repeat cycle. The spacecraft is a high-heritage low earth orbit Star-2, provided by Orbital Sciences Corporation. Its single instrument incorporates three high-resolution grating spectrometers, designed to measure the near-infrared absorption by CO<sub>2</sub> and molecular oxygen in reflected sunlight. The orbit's early afternoon equator crossing time maximizes the available signal and minimizes diurnal biases in CO<sub>2</sub> measurements associated with photosynthesis.

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Formulation:** Orbiting Carbon Observatory

### Schedule

| Date   | Key Milestones              | Change From FY 2005 |
|--------|-----------------------------|---------------------|
| Apr 05 | Mission Confirmation Review |                     |
| Oct 07 | Launch                      |                     |

### Strategy For Major Planned Acquisitions

- There are no planned major procurements, as all instrument and spacecraft contracts are in place.

### Key Participants

- There are no development partners outside of NASA.
- New Zealand's National Institute of Water and Atmospheric Research, France's Laboratoire des Sciences du Climat et de l'Environnement, and Germany's University of Bremen are all members of the OCO Science Team.

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Formulation:** Hydros

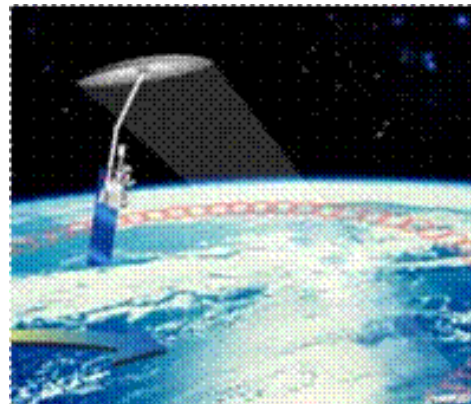
**President's FY 2006 Budget Request**

(Dollars in Millions)

| Hydros                       | FY2004 | FY2005 | FY2006 |
|------------------------------|--------|--------|--------|
| FY 2006 PRES BUD             |        |        | 4.6    |
| Changes from FY 2005 Request |        |        |        |

**Overview**

The Hydrosphere State (Hydros) mission is part of ESSP. Hydros was competitively selected from proposals submitted in response to ESSP Announcement of Opportunity 3. Hydros will provide global views of the terrestrial water cycle, soil moisture content and its freeze/thaw state. The science goals for Hydros are to: provide resolution of the terrestrial water budget mean state and variability, improve water supply forecasts for water management and agriculture, and enhance predictive skill (lead time and accuracy) for weather, climate, and carbon balance. The science of Hydros introduces improved capability to predict costly natural hazards, such as extreme weather, floods, and droughts. This Project supports Objective 14 and APG 6ESS25.



**Hydros**

For more information, please see [http://sciencedev.hq.nasa.gov/missions/satellite\\_62.htm](http://sciencedev.hq.nasa.gov/missions/satellite_62.htm).

Image of the Hydros Spacecraft

**Changes From FY 2005**

- Hydros was competitively selected from proposals submitted in response to ESSP Announcement of Opportunity 3.

**Program Management**

Project management responsibility resides at JPL. The NASA and JPL Program Management Councils have program oversight responsibility.

**Technical Description**

Hydros will be launched into a polar, sun synchronous orbit that allows global measurements of Earth's changing soil moisture and land surface freeze/thaw conditions. The payload on Hydros will consist of an L-band radar and radiometer with a shared 6-meter rotating antenna. The Hydros satellite is planned to operate for two years. The combined readings from the radar and radiometer will provide data through most vegetation and will provide soil moisture measurements to a greater depth than any other space based system.

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Formulation:** Hydros

### Schedule

| Date   | Key Milestones              | Change From FY 2005 |
|--------|-----------------------------|---------------------|
| Jul 07 | Mission Confirmation Review |                     |
| Dec 10 | Launch                      |                     |

### Strategy For Major Planned Acquisitions

- Project selection of the antenna vendor will be conducted in FY 2006 via full and open competition.

### Key Participants

- MIT provides the PI and contributes to the science team and science operations.
- CSA provides the Antenna Feed Assembly and radar processing (Memorandum of Understanding not finalized).

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Formulation:** Aquarius

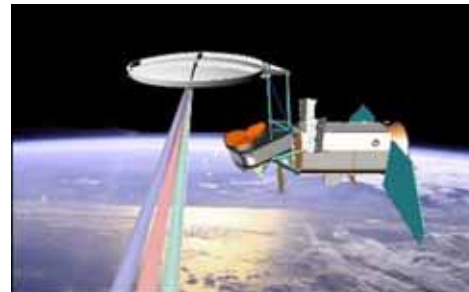
**President's FY 2006 Budget Request**

(Dollars in Millions)

| <u>Aquarius</u>              | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> |
|------------------------------|---------------|---------------|---------------|
| FY 2006 PRES BUD             | 8.1           | 19.1          | 55.3          |
| Changes from FY 2005 Request | -0.1          | -1.4          |               |

**Overview**

The Aquarius Mission is part of ESSP. Aquarius was competitively selected from proposals submitted in response to ESSP Announcement of Opportunity 3. Aquarius is an instrument on the Argentine Comisión Nacional de Actividades Espaciales (CONAE) spacecraft SAC-D. Aquarius will make space-based measurements of sea surface salinity (SSS), with high accuracy and resolution to investigate the links between the global water cycle, ocean circulation, and climate. The objective of Aquarius is to observe and model seasonal and year-to-year variations of SSS, and how these relate to changes in the water cycle and ocean circulation. This will yield an unprecedented view of the oceans' role in climate and weather. This project supports Objective 14 and APG 6ESS25.



For more information, please see [http://sciencedev.hq.nasa.gov/missions/satellite\\_59.htm](http://sciencedev.hq.nasa.gov/missions/satellite_59.htm).

Image of the Aquarius Spacecraft

**Changes From FY 2005**

- Mission Confirmation Review rephased to occur June 2005.

**Program Management**

Aquarius is led by a PI from Earth and Space Research. Project management and Program Management Council responsibility reside at JPL.

**Technical Description**

This observatory will be launched into a polar, sun-synchronous orbit that allows global coverage of ice free ocean surfaces, consistent with SAC-D science observational targets. The Aquarius mission will provide for a 3-year data set. CONAE will conduct the operations. Aquarius will deploy an integrated passive/active L-band radiometer/scatterometer as the primary salinity-measuring payload. JPL will design and build the scatterometer which will utilize surface radar backscatter for mitigating salinity measurement errors due to surface roughness effects. GSFC will design and build the L-Band radiometer which will provide the primary sea surface brightness measurement used to derive SSS.

**Theme:** Earth-Sun System  
**Program:** Earth System Science Pathfinder  
**Project In Formulation:** Aquarius

### Schedule

| Date   | Key Milestones              | Change From FY 2005    |
|--------|-----------------------------|------------------------|
| Jun 05 | Mission Confirmation Review | -2 months (correction) |
| Sep 08 | Launch                      | No change              |

### Strategy For Major Planned Acquisitions

- There are no planned major procurements, as all instrument and spacecraft contracts are in place.

### Key Participants

- CONAE will provide the spacecraft, ground systems, and operations.



**Theme:** Constellation Systems  
**Program:** Earth Orbit Capability (Spiral 1)  
**Project In Formulation:** Crew Exploration Vehicle (Spiral 1)

**President's FY 2006 Budget Request**

(Dollars in Millions)

| Crew Exploration Vehicle (Spiral 1) | FY2004 | FY2005 | FY2006 |
|-------------------------------------|--------|--------|--------|
| FY 2006 PRES BUD                    | 75.0   | 140.1  | 752.9  |
| Changes from FY 2005 Request        | 75.0   | 140.1  |        |

**Overview**

The Crew Exploration Vehicle (CEV) will provide human transportation capability from the surface of the Earth to orbit by 2014. It will be designed from the outset as a key element of the Constellation System of Systems and will provide the capability for human transportation beyond Earth orbit by no later than 2020. The capabilities of the CEV will be extensible to future missions in a sustainable, affordable manner as new technology becomes available. The CEV will provide a flexible crew vehicle capable of supporting multiple exploration missions to orbital destinations such as the Moon, Mars and beyond.

The CEV Project Office was established at NASA Headquarters within the Constellation Systems Theme in FY 2004. The CEV project has recruited a diverse team of experts from across the NASA Centers and brought them together at NASA Headquarters to develop a Request for Proposal for the CEV prime contractors. The CEV Request for Proposal will be released in March 2005 with a planned award in September 2005. NASA anticipates multiple awards that will continue up to Preliminary Design Review with a down-select following a flight test to demonstration risk reduction for the CEV in 2008.



The Crew Exploration Vehicle is the centerpiece of the Constellation System of Systems.

The CEV project supports the Orbit Capability (Spiral 1) Program by providing the vehicle needed to demonstrate an Earth orbit capability, leading to a mission to the lunar surface.

For more information, please see <http://exploration.nasa.gov/constellation/index.html>.

**Changes From FY 2005**

- Since last year the program has established the CEV Project Office, developed a detailed acquisition strategy, and initiated formulation of the CEV prime contractor Request for Proposal.

**Program Management**

The CEV project is currently being managed from NASA Headquarters by ESMD, with future participation from the Space Operations Mission Directorate.

**Theme:** Constellation Systems  
**Program:** Earth Orbit Capability (Spiral 1)  
**Project In Formulation:** Crew Exploration Vehicle (Spiral 1)

**Technical Description**

The CEV will be designed to: optimize crew safety while ensuring affordability and extensibility to future spirals; maximize the use of existing technology; maximize vehicle flexibility by employing an open systems architecture; and employ a simplified interface design with the crew launch vehicle. The CEV will be certified by testing to the maximum extent possible, and design of the CEV and its ground systems will be focused on achieving innovative and streamlined operations in order to reduce operational costs.

**Schedule**

| Date     | Key Milestones                                   | Change From FY 2005 |
|----------|--|---------------------|
| Mar 2005 | Release Request for Proposal for CEV development | None                |
| Sep 2005 | Award contract for CEV (Spiral 1) development    | None                |
| 2006     | CEV System Readiness Review                      | None                |
| 2008     | CEV Preliminary Design Review                    | None                |
| 2008     | Risk Reduction Flight Demonstration              | None                |

**Strategy For Major Planned Acquisitions**

- FY 2005 - Release and award multiple contracts for CEV phase 1 design and flight demonstration through Preliminary Design Review in 2008.

**Key Participants**

- Participants include eleven Concept Refinement and Exploration teams from industry and academia, and NASA insight through Integrated Product Teams.

**Theme:** Constellation Systems  
**Program:** Earth Orbit Capability (Spiral 1)  
**Project In Formulation:** Crew Launch Vehicle (Spiral 1)

**President's FY 2006 Budget Request**

(Dollars in Millions)

| Crew Launch Vehicle (Spiral 1) | FY2004 | FY2005 | FY2006 |
|--------------------------------|--------|--------|--------|
| FY 2006 PRES BUD               |        | 11.1   | 14.3   |
| Changes from FY 2005 Request   |        | 11.1   |        |

**Overview**

The Crew Launch Vehicle (CLV) supports the Vision for Space Exploration by providing routine, safe, affordable, and reliable transportation of humans to low Earth orbit. The CLV will be evolvable in a sustainable and affordable manner to support future requirements. A key element of the Constellation System of Systems, the CLV will safely provide the necessary propulsive power to accelerate the CEV to low Earth orbit. Systems that comprise the CLV include the airframe structure and mechanisms (e.g. core stage, strap-on boosters, and upper stage), propulsion system (propellant distribution and engines), thermal management system, avionics (guidance, navigation and control), payload fairing, and system health management. The CLV also includes the launch vehicle element unique ground launch systems embedded in the ground infrastructure. The CLV will be integrated with ground support systems and the CEV for pre-launch preparations and airborne support (tracking, telemetry, range, recovery, etc.) during flight. The launch system architecture selected will meet the human-rating requirements, but may also have the capability to evolve to later cargo carrying requirements of future spirals. For more information, please see <http://exploration.nasa.gov/constellation/index.html>.



The Crew Launch Vehicle will provide a launch capability to enable humans to begin their exploration journey.

**Changes From FY 2005**

- Formulation of the CLV acquisition strategy is being developed based on the lunar architecture analysis of alternatives to be completed in FY 2005.

**Program Management**

The CLV project is currently managed out of Headquarters by ESMD, with coordination and participation from the Space Operations Mission Directorate.

**Technical Description**

The CLV will meet key parameters such as: design for crew safety while ensuring a reasonable, feasible architecture (e.g. engine out capability, abort capability, etc.); mass-to-orbit, design reliability, minimal infrastructure requirements and standard payload interfaces; optimal functional allocations between the launch system and all other system interfaces; minimal and simple interfaces between the launch system and the CEV for optimum integration; minimal and simple interfaces between the launch system and the ground support system to allow for responsive and safe operations; and execution of a risk mitigation ground and flight test program to verify human-rating certification of the system.

**Theme:** Constellation Systems  
**Program:** Earth Orbit Capability (Spiral 1)  
**Project In Formulation:** Crew Launch Vehicle (Spiral 1)

### Schedule

| Date | Key Milestones                                   | Change From FY 2005 |
|------|--|---------------------|
| 2006 | Release Request for Proposal for CLV development | None                |
| 2007 | Award contract for CLV development               | None                |

### Strategy For Major Planned Acquisitions

- FY 2006 - Release Request for Proposals for 2014 crew launch capability
- FY 2007 - Award contract for the CLV

### Key Participants

- NASA is still developing its strategy for providing a crew launch capability. The BAA and RFP processes are part of the way NASA will dialogue with the broad external community to ensure that this capability is acquired in the most effective and efficient way possible for NASA and the Nation.
- Key participants are the Exploration Systems Mission Directorate, the Space Operations Mission Directorate, NASA Centers participation through Integrated Product Teams, and the launch vehicle industry.

**Theme:** International Space Station  
**Program:** International Space Station Program  
**Project In Development:** Core Development

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

| Core Development             | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 |
|------------------------------|--------|--------|--------|--------|--------|--------|--------|
| FY 2006 PRES BUD             | 83.9   | 96.2   | 74.3   | 63.4   | 50.8   | 23.8   | 19.7   |
| Changes from FY 2005 Request | -17.4  | 26.8   | 8.8    | 7.6    | 28.4   | 8.1    |        |

**Overview**

Space Station elements are provided by U.S. and international partners Russia, Europe, Japan, and Canada. The U.S. elements include nodes, laboratory module, airlock, truss segments, photovoltaic arrays, three pressurized mating adapters, unpressurized logistics carriers, and a cupola. Various systems have been developed by the U.S., including thermal control, life support, navigation, command and data handling, power systems, and internal audio/video. Other U.S. elements being provided through bilateral agreements include the pressurized logistics modules provided by the Italian Space Agency, Node 2 provided by ESA, and the centrifuge accommodation module (CAM)/centrifuge provided by the Japanese. During FY 2005, it is expected the Space Shuttle will return to flight and the assembly of the ISS will resume in FY 2006. In the meantime, the ISS will continue on-orbit research operations with two crew and with resupply and crew rotation provided by Russian Progress and Soyuz vehicles.



ISS EVA operation.

**Changes From FY 2005**

- Shuttle Return to Flight in FY 2005
- NASA is examining configurations for the Space Station that meet the needs of both the space exploration vision and our international partners using as few Shuttle flights as possible.
- Columbia and Full Cost Impacts have significantly reduced program reserves.

**Program Management**

JSC is responsible for management of ISS core development. The NASA and JSC management Councils have program oversight responsibility.

**Technical Description**

The primary objective of the ISS is to support scientific research and other activities requiring the unique attributes of humans in space. In concert with the new exploration vision, NASA will refocus U.S. Space Station research on activities, such as the development of countermeasures against space radiation and the long-term effects of reduced gravity, that prepare human explorers to travel beyond low Earth orbit.

**Theme:** International Space Station  
**Program:** International Space Station Program  
**Project In Development:** Core Development

### Schedule

| Date           | Key Milestones             | Change From FY 2005         |
|----------------|----------------------------|-----------------------------|
| December 2005  | Flight 12A - P3/P4 Truss   | Dates are subject to change |
| February 2006  | Flight 12A.1 - P5 Truss    | Dates are subject to change |
| April 2006     | Flight 12A/1 - S3/S4 Truss | Dates are subject to change |
| June 2006      | Flight 13A.1 - S5 Truss    | Dates are subject to change |
| September 2006 | Flight 15A - S6 Truss      | Dates are subject to change |
| December 2006  | Flight 10A - Node 2        | Dates are subject to change |

### Strategy For Major Planned Acquisitions

- None

### Key Participants

- International Partners; There are a total of 16 participating nations working on the ISS. Russia, ESA, Japan, Canada, and Italy are providing elements for the international Space Station
- Boeing; Prime contractor for International Space Station Development and Sustaining Engineering.
- Russia; in addition to ISS elements and crew members, Soyuz and Progress have provided critical crew rotation and resupply during the Shuttle hiatus.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior    | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total    | Comments |
|---------------------------|----------|--------|--------|--------|--------|--------|--------|--------|-----|----------|----------|
| FY 2006 PRES BUD          | 12,515.4 | 83.9   | 96.2   | 74.3   | 63.4   | 50.8   | 23.8   | 19.7   |     | 12,927.4 |          |
| Changes                   | 0.0      | -17.4  | 26.8   | 8.8    | 7.6    | 28.4   | 8.1    |        |     | 82.0     |          |
| FY2005 President's Budget | 12,515.4 | 101.3  | 69.4   | 65.5   | 55.8   | 22.4   | 15.7   |        |     | 12,845.5 |          |

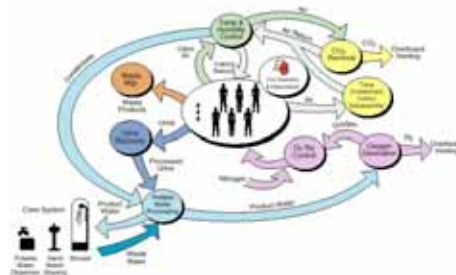
**Theme:** International Space Station  
**Program:** International Space Station Program  
**Project In Development:** Environmental Control and Life Support System (ECLSS)

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

| <u>Environmental Control and Life Support System (ECLSS)</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|--|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD   | 25.7          | 10.4          | 18.1          | 8.1           | 4.0           | 3.4           | 2.5           |
| Changes from FY 2005 Request                                 | 6.4           | -0.8          | 8.8           | 4.4           | 4.0           | 3.4           |               |

**Overview**

ISS Capability Upgrades enable potential enhancements to support research required by the National Vision for Space Exploration. NASA and the International Partners hope to increase the permanent crew of the ISS to greater than three. The additional crew is vital to full utilization of ISS capabilities for U.S. Exploration and International Partner goals. Development funding for the expansion of crew size above the U.S. Core baseline is included in the FY 2006 Capability Upgrades budget. Operations and sustaining will be included in the ISS operations budget. Regenerative environmental control and life support system (ECLSS), Node 3, and habitability modifications were funded from reserves in FY 2005, and the final design will be based on the ISS final configuration that emerges from the current reassessment.



Regenerative ECLSS.

**Changes From FY 2005**

- ECLSS, Node 3 and Habitability are included in the ISS program baseline
- ECLSS to be installed in the lab to provide early O2 generation capability.

**Program Management**

JSC has overall program management responsibility with MSFC providing the management of ECLSS development.

**Technical Description**

ECLSS, Node 3 and Habitability upgrades will provide the ability to sustain a crew size above three during continuous ISS operations. ECLSS provides a critical test bed for exploration and will provide redundancy from the Russian Electron for Oxygen generation up to 7,500 pounds. In addition the ECLSS will be able to recycle up to 41K of water. The habitability upgrades will provide crew accommodations and the Node 3 and additional 3470 cubic feet of volume.

**Theme:** International Space Station  
**Program:** International Space Station Program  
**Project In Development:** Environmental Control and Life Support System (ECLSS)

### Schedule

| Date          | Key Milestones                               | Change From FY 2005 |
|---------------|--|---------------------|
| March 2005    | Oxygen Generator Assembly On Dock at MSFC    | New Milestone       |
| May 2005      | Urine Processor Assembly bench test complete | Delayed four months |
| December 2005 | Oxygen Generation System delivery to KSC     | New Milestone       |
| March 2006    | Water Recovery System delivery to KSC        | New Milestone       |
| January 2008  | Node 3 delivery to KSC                       | None                |

### Strategy For Major Planned Acquisitions

- None

### Key Participants

- Hamilton Sundstrand; performing major ECLSS orbital replacement unit development and rack level integration for two of three racks.
- Boeing; providing critical software and hardware for Node 3 and ECLSS integration to ISS
- Alenia; building Node 3 under contract with ESA.

### Risk Management

- RISK: The Advanced ECLSS is a vital new technology. Development has seen technical challenges associated with delivery of key system components. These challenges are impacting program schedule. Delivery of the ECLSS could be impacted which would delay back up O2 regeneration capability or greater than three crew capability. MITIGATION: The program provides weekly status on all ECLSS technical issues with available schedule slack. Technical work arounds are currently in place with some contingency remaining.

### Budget Detail/Life Cycle Cost (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|-------|----------|
| FY 2006 PRES BUD          | 206.0 | 25.7   | 10.4   | 18.1   | 8.1    | 4.0    | 3.4    | 2.5    |     | 278.2 |          |
| Changes                   |       | 6.4    | -0.8   | 8.8    | 4.4    | 4.0    | 3.4    |        |     | 28.7  |          |
| FY2005 President's Budget | 206.0 | 19.3   | 11.2   | 9.3    | 3.7    |        |        |        |     | 249.5 |          |



**Theme:** International Space Station  
**Program:** International Space Station Program  
**Project In Development:** ISS Cargo and Crew Services

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

| <u>ISS Cargo and Crew Services</u> | <u>FY2004</u> | <u>FY2005</u> | <u>FY2006</u> | <u>FY2007</u> | <u>FY2008</u> | <u>FY2009</u> | <u>FY2010</u> |
|------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| FY 2006 PRES BUD                   |               | 98.0          | 160.0         | 160.0         | 160.0         | 500.0         | 720.0         |
| Changes from FY 2005 Request       |               | -42.0         | 0.0           | 0.0           | 0.0           | 0.0           |               |

**Overview**

A key element in the future of the ISS program is the purchase of alternate cargo and crew transportation services to supplement the Shuttle when it is in service, and to replace it when it retires. The Space Shuttle has been the primary U.S. transportation vehicle for assembly and operation of the Space station since 1998 when STS-88 delivered and mated the Unity node to the Russian Control module, Zarya. NASA plans to continue use of the Space Shuttle as the workhorse vehicle for transporting large cargo to complete the assembly of the space station by the end of this decade. In 2010, the Space Shuttle - after nearly 30 years of duty - will be retired from service. Other U.S. systems to deliver crew and cargo to the ISS do not currently exist. It is necessary for NASA to establish a transportation capability for crew and cargo for the space station program both during ISS assembly and after the Shuttle is retired. NASA intends to meet this need through the purchase of services for cargo and crew transport using existing and emerging capabilities, both domestic and foreign. The purchase of these services is necessary to enable new ISS science capabilities, deliver and retrieve cargo, and provide human-rated crew transport for enterprise crew rotation when the Shuttle and partner-provided transportation is insufficient to meet space station requirements.

**Changes From FY 2005**

- A Cargo/Crew Services Aquisition Strategy has been developed

**Program Management**

ISS Program Office will manage program requirements and the Launch Services Program will manage the acquisition.

**Technical Description**

NASA intends to solicit a Request for Proposal (RFP) for commercial cargo transportation services to the ISS NLT June/July 2005 with an award expected by December 2005. The initial commercial cargo transportation system operational capability is expected NLT 2009.

**Theme:** International Space Station  
**Program:** International Space Station Program  
**Project In Development:** ISS Cargo and Crew Services

**Schedule**

| Date          | Key Milestones    | Change From FY 2005 |
|---------------|-------------------|---------------------|
| March 2005    | Draft RFP release | New Milestone       |
| June 2005     | Final RFP release | New Milestone       |
| December 2005 | Contract Awards   | New Milestone       |

**Strategy For Major Planned Acquisitions**

- ISS Cargo Acquisition: To be selected by full and open competition.

**Budget Detail/Life Cycle Cost** (Dollars in Millions)

| Budget Authority          | Prior | FY2004 | FY2005 | FY2006 | FY2007 | FY2008 | FY2009 | FY2010 | BTC | Total   | Comments |
|---------------------------|-------|--------|--------|--------|--------|--------|--------|--------|-----|---------|----------|
| FY 2006 PRES BUD          |       |        | 98.0   | 160.0  | 160.0  | 160.0  | 500.0  | 720.0  |     | 1,798.0 |          |
| Changes                   |       |        | -42.0  |        |        |        |        |        |     | 678.0   |          |
| FY2005 President's Budget |       |        | 140.0  | 160.0  | 160.0  | 160.0  | 500.0  |        |     | 1,120.0 |          |



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