



### THEMES



**Human and  
Robotic  
Technology**



**Transportation  
Systems**

Future exploration missions into the solar system and beyond will employ humans where their capabilities are unique and critical. Among those capabilities are their physical adaptability, intellectual flexibility, capacity for innovation in operations, and ability to inspire Earth's population. NASA's missions will also employ increasingly capable robotic spacecraft, which will execute science activities and infrastructure functions using revolutionary advances in power, propulsion, intelligence, mobility, and communications. As a result of current investments in Exploration Systems Enterprise programs, today's youth will watch humans explore Mars in their lifetime and will see their understanding of the Universe expand through scientific discoveries we have not yet imagined.

# EXPLORATION SYSTEMS

## PURPOSE

The relationship between discovery and exploration has driven human curiosity throughout global and American history. New World pioneers and American frontiersmen demonstrated the great value of exploration, as they obtained knowledge, technology, resources, and inspiration for our nation. At the beginning of the 21st century, we stand at a unique time in our exploration of the heavens. The exploratory voyages of the next few decades have the potential – within our lifetimes – to answer age-old questions about how life begins, whether life exists elsewhere, and how humans will exist in the future.

These voyages will not be easy. Mars is 100,000 times farther away from Earth than is the International Space Station. At the moons of Jupiter, the power supplied by sunlight is 27 times weaker than on Earth. Radiation presents an ever-present challenge to human and robotic explorers. Using existing systems and technology, it takes over a decade-and-a-half to reach the boundaries of our solar system.

To enable an effective and exciting program of solar system exploration, the constraints of distance, energy, and time must be overcome. Meeting these challenges will require innovative approaches, new vehicles, and breakthrough technologies. The Exploration Systems Enterprise is responsible for developing and demonstrating the strategies and systems that will allow human and advanced robotic exploration of other worlds. Consistent with the National Space Exploration Policy, the NASA Strategic Plan, and the Vision for Space Exploration, the Exploration Systems Enterprise will:

**Support Research at Key Research Destinations:** The development of exploration strategies, systems, and technologies will be guided by requirements for conducting research at key destinations in the search for habitable environments and life. These destinations include, but are not limited to, the Moon, the planet Mars, the moons of Jupiter and other outer planets, and deep space telescopes that will search for planets outside our solar system.

**Enable Sustainable Exploration:** Exploration architectures and vehicles will be developed with the goal of enabling sustainable, affordable, and flexible exploration of the solar system.

**Employ Humans and Robots:** Exploration Systems will design architectures and missions that use humans and robots in partnership, leveraging the capabilities of each where most useful.

## Enterprise: Exploration Systems

**Use the Moon as a Testing Ground for Mars and Beyond:** The Exploration Systems Enterprise, working with the Lunar Exploration and Mars Exploration Themes, will use robotic and human missions to further science, and to develop and test new approaches, technologies, and systems, including the use of lunar and other space resources, to support sustained human space exploration of Mars and other destinations.

**Management Philosophy:** The Exploration Systems Enterprise will be guided by a philosophy that ensures that operators and technologists work together to enable the leveraging of technology research and development. Technology will be matured prior to development through performance demonstration. A disciplined Strategy-to-Task-to-Technology process will be instituted for purposes of requirements definition. Rigorous trade study analysis, utilizing modeling and simulation, will be performed by operators and technologists jointly. A focused program management process, using best practices such as earned value management, will be at the core of this enterprise.

**Work Closely With Customers and Partners:** The Exploration Systems Enterprise will work closely with NASA's Space Architect, Space Science Enterprise, Biological and Physical Research Enterprise, Space Flight Enterprise, other government agencies, potential international partners, academia, and industry in the development of new exploration strategies, architectures, vehicles, systems, and technologies.

The Exploration Systems Enterprise includes two new Themes that will function cooperatively to enable sustainable exploration and scientific discovery in the solar system and beyond. The Themes are Human and Robotic Technology and Transportation Systems.

### FY 2003 ACCOMPLISHMENTS

Exploration Systems is a new Enterprise. Planned FY 2004 accomplishments are described below.

### THEME DISTRIBUTION

Budget Authority (\$ in millions)	FY 2003	FY 2004	FY 2005
Human and Robotic Technology		679.3	1,093.7
Transportation Systems		966.5	688.7
Total		1,645.8	1,782.4

Note: For all formats, the FY 2003 column reflects the FY 2003 Congressional Operating Plan, dated 9/04/03. The FY 2004 column reflects the FY 2004 Conference committee report. The FY 2005 column represents the FY 2005 President's Budget Submit.

Indicates budget numbers in full cost

### Human and Robotic Technology

The Human and Robotic Technology (HRT) Theme is responsible for developing innovative technologies to enable sustainable exploration of our solar system. Through applied technology research, focused technology maturation, and timely technology transition, the HRT Theme will develop technologies that can be integrated into LE Theme missions and applied in the exploration activities of other NASA Enterprises.

For sustainable solar system exploration, NASA requires safe, affordable, effective, and flexible architectures, vehicles, and systems. This may require systems that can be reused, systems that are highly reliable and require limited maintenance and support, systems that can be applied to more than one destination, systems that can operate intelligently without human control, and/or architectures that use space resources to improve efficiency. NASA plans to invest in a number of new approaches and technologies for exploration that could enable these kinds of architectures, vehicles, and systems. These technologies will be demonstrated on the ground, at the Space Station and other locations in Earth orbit, and at the Moon starting this decade and into the next. Where they provide for safety, affordability, effectiveness, and flexibility in architectures, these new tools will be incorporated in full-scale, operational exploration systems.

The HRT Theme consists of five programs: Centennial Challenges, Project Prometheus, Technology Maturation, Advanced Space Technology, and Innovative Technology Transfer Partnerships.

### OVERALL BUDGET

FY 2005 request is \$1,093.7 million (full cost).

#### Centennial Challenges

Request includes funding to establish a series of annual prizes for revolutionary, breakthrough accomplishments that advance exploration of the solar system and beyond and other NASA goals. Some of the most difficult technical challenges to exploration will require very novel solutions from non-traditional sources of innovation. By making awards

## **Enterprise: Exploration Systems**

based on actual achievements instead of proposals, NASA will tap innovators in academia, industry, and the public who do not normally work on NASA issues. Centennial Challenges will be modeled on past successes, including 19th century navigation prizes, early 20th century aviation prizes, and more recent prizes offered by the U.S. government and private sector. Examples of potential Centennial Challenges include very-low-cost space missions, contests to demonstrate highly mobile, capable, and survivable robotic systems, and fundamental advances in technical areas like lander navigation, spacecraft power systems, life detection sensors, and nano-materials.

### ***Project Prometheus***

Request includes funding for development of space nuclear fission power systems and space nuclear propulsion systems to support advanced robotic and human exploration of the solar system. These technologies are critical to in-depth robotic exploration of the outer solar system, power for sustained human planetary surface operations, and propulsion for human exploration missions. The technologies developed by Project Prometheus will be first demonstrated on NASA's Jupiter Icy Moons Orbiter (JIMO) mission during the next decade and applied to future robotic and human missions thereafter.

Project Prometheus was previously managed by NASA's Space Science Enterprise. The Space Science Enterprise retains funding for JIMO instrumentation and research, and Project Prometheus will continue to work closely with the Space Science Enterprise to enable the JIMO mission.

### ***Technology Maturation***

Request includes funding for development and demonstration of novel concepts and technologies for sustainable exploration of our solar system. Historically, the development of new space technologies from initial research to mission application is a difficult process. Enabling safe, affordable, effective, and flexible exploration architectures, vehicles, and systems will require a robust, ongoing commitment to focused innovation. Funding assumes architecture and systems design, technology research and development, and ground and in-space demonstration activities this decade in areas like robotic networks, propellant pre-positioning, advanced power and propulsion, in-space assembly, and space resource utilization. Technology Maturation will work closely with other programs developing and demonstrating breakthrough exploration technologies, including Lunar Exploration, Project Prometheus, Mars Exploration Program, and the Astronomical Search for Origins.

Working with NASA and non-NASA researchers and technologists, through both directed investments and partnerships, Technology Maturation will advance a range of high-leverage technologies and space operations concepts, mature and validate key technologies, and transition them into applications. Technology Maturation will coordinate with the NASA Space Architect, NASA's Space Science and Biological and Physical Research Enterprises, other government agencies, industry, academia, and potential international partners to leverage common requirements and identify innovative ideas.

### ***Advanced Space Technology***

Request includes funding for research and development of high-leverage space technologies to support solar system exploration and other NASA applications. Advanced Space Technology will conduct fundamental research, technology development, and tool development in areas like in-space computing, space communications and networking, sensors, modular systems, and engineering risk analysis. Advanced Space Technology will work closely with Technology Maturation to identify technologies to meet solar system exploration needs.

Advanced Space Technology incorporates the previous Mission and Science Measurement Theme from the former Aerospace Technology Enterprise. The Exploration Systems Enterprise will review ongoing Mission and Science Measurements Technology projects and processes in 2004 to determine which will be carried forward into the Advanced Space Technology Program. This review will leverage the findings published recently at the conclusion of the National Research Council's review of Mission and Science Measurement program activities. Program Management will, to the extent feasible, openly compete research funding so that R&D work is carried out by the best researchers and technologists in academia, industry, NASA field centers, and other government agencies.

### ***Innovative Technology Transfer Partnerships***

Request includes funding for joint technology development agreements with industry, NASA's Small Business Innovation Research and Small Business Technology programs, and other regulatory technology transfer requirements at NASA. Innovative Technology Transfer Partnerships will provide technological solutions for meeting solar system exploration and other NASA needs through novel partnerships with the non-aerospace industrial firms, the venture capital community, small businesses, and universities.

The Innovative Technology Transfer Partnerships program incorporates the previous Innovative Technology Transfer Partnerships Theme from the former Aerospace Technology Enterprise. Enterprise reviews in CY 2004 will align ongoing activities in Innovative Technology Transfer Partnerships.

## Enterprise: Exploration Systems

### Transportation Systems

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The Transportation Systems (TS) Theme will provide crew transfer and other NASA-unique space transportation capabilities to support exploration of the solar system. The near-term activities of the TS Theme will be focused on development and demonstration of a Crew Exploration Vehicle (CEV) that can transport and support human crews traveling to destinations beyond low Earth orbit. The TS Theme will also be responsible for planning for potential future NASA-unique space transportation needs, such as in-space transportation systems and heavy lift launch systems, that cannot be met through commercial or international partner capabilities.

The TS Theme includes transition and closeout activities for the Space Launch Initiative Theme of the former Aerospace Technology Enterprise, including the Orbital Space Plane and Next Generation Launch Technology programs.

### OVERALL BUDGET

FY 2005 request is \$688.8 million (full cost).

#### *Crew Exploration Vehicle*

The CEV will support human missions to the Moon and later to the planet Mars and other deep space destinations. The CEV might also supplement international partner crew transport systems to the Space Station. CEV capabilities will be demonstrated in phases with the following major milestones:

- 2008 – First Unmanned Prototype Test Flight.
- 2010 – Initiate Advanced Test Flights.
- No Later Than 2014 – Initial Human-rated Capability.