Theme Overview

Planetary Science is a grand human enterprise that seeks to discover the nature and origin of the celestial bodies among which we live, and to explore whether life exists beyond Earth. The scientific imperative for Planetary Science, the quest to understand our origins, is universal. How did we get here? Are we alone? What does the future hold? These overarching questions lead to more focused, fundamental science questions about our solar system: How did the Sun's family of planets and minor bodies originate? How did the solar system evolve to its current diverse state? What are the characteristics of the solar system that led to the origin of life? How did life begin and evolve on Earth and has it evolved elsewhere in the solar system? What are the hazards and resources in the solar system environment that will affect the extension of human presence into space?

To achieve progress in addressing these six fundamental science questions, NASA relies on a balanced program. There are seven programs within the Planetary Science Theme: Research, Lunar Quest, Discovery, New Frontiers, Mars Exploration, the Outer Planets, and the Technology Programs. Research supports two operating missions with international partners (Rosetta and Hayabusa), as well as Research and Analysis, Sample and Data Curation, data dissemination and analysis. The Lunar Quest Program consists of small robotic spacecraft missions, Missions of Opportunity, the Lunar Science Institute, and Research & Data Analysis. Discovery has two operating spacecraft (MESSENGER and Dawn), one radar instrument operating on an ESA Mars Express mission (ASPERA-3), one mission in its development phase (GRAIL), and four Missions of Opportunities (M3, EPOCH, DIXI, NExT). New Frontiers has one operating spacecraft (New Horizons) and one mission (Juno) currently in its development phase. The Mars Exploration Program has two spacecraft (Odyssey and MRO) and two rovers (Spirit and Opportunity) in operation, one instrument operating on an ESA mission (Mars Express), one mission in development (MSL), one mission in formulation (MAVEN), and project activities for technology, next decade mission design/development, and research. The Outer Planets Program includes research, one operating mission (Cassini) and an Outer Planets Flagship mission under study. Technology Program includes in-space propulsion systems, advanced power generation, and the advanced multi-mission support.

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**1,312.6**	**1,325.6**	**1,346.2**	**1,500.6**	**1,577.7**	**1,600.0**	**1,633.2**
Planetary Science Research	183.1	162.1	161.7	193.5	240.2	232.6	254.2
Lunar Quest Program	41.3	105.0	103.6	142.6	138.6	145.5	118.7
Discovery	136.4	247.0	213.2	234.6	256.8	256.5	264.3
New Frontiers	115.1	263.9	264.1	239.9	294.2	239.8	249.6
Mars Exploration	709.3	381.6	416.1	494.5	405.5	514.3	536.7
Outer Planets	62.2	101.1	98.6	97.1	140.3	117.7	118.5
Technology	65.2	64.9	89.0	98.4	102.1	93.5	91.4
FY 2009 President's Budget Request	**1,247.5**	**1,334.2**	**1,410.1**	**1,537.5**	**1,570.0**	**1,608.7**	**--**
Planetary Science Research	242.1	270.8	315.8	355.6	373.2	382.6	--
Discovery	153.0	247.0	258.3	256.0	326.1	140.5	--
New Frontiers	132.2	263.9	250.3	232.3	227.7	236.9	--
Mars Exploration	553.5	386.5	299.6	344.5	341.1	413.8	--
Outer Planets	81.9	101.1	216.7	279.4	230.6	362.0	--
Technology	84.8	64.9	69.3	69.6	71.3	73.0	--
Total Change from FY 2009 Request	**65.2**	**-8.6**	**-63.8**	**-36.8**	**7.7**	**-8.7**	**--**

Note: The human space flight review being undertaken during the summer of 2009 may result in changes to the International Lunar Network and robotic lunar exploration program. NASA will notify Congress if there are any changes to the request. Starting in FY 2010, the NEOO project is budgeted in the Planetary theme.

Plans for FY 2010

Planetary Science Research

Two new changes are included in the Planetary Science Research Program FY 2010 budget; Lunar Science transferred to the Lunar Quest Program (LQP), and the Near Earth Objects Observations (NEOO) project transferred from Earth Science to Planetary Science. The Research and Analysis program will continue to release research announcements and make selections. The Planetary Data System will continue to archive and release planetary science data to the science community in a timely manner for further scientific analysis. The Astromaterial Curation project will continue its efforts on curation and distribution of solar system samples (Astromaterials) returned by NASA planetary missions such as Stardust and Genesis. The Rosetta project will continue to support fly-by of Asteroid Lutetia (November 2010), and Hayabusa (MUSES-C) will continue to provide navigation, Deep Space Network tracking and science analysis support to JAXA to support an Earth Return in 2010. NEOO will continue to detect impact hazards to the Earth.

Lunar Quest Program

The Lunar Quest Program (LQP), previously the Lunar Science Project, is now moved to its own stand-alone budget and program line. Project elements under LQP includes the Lunar Atmosphere and Dust Environment Explorer (LADEE) and the International Lunar Network (ILN) missions, and the Lunar Science Research. LADEE will complete its preliminary design review in 2009 and will enter Implementation Phase (KDP-C) in FY 2010. The ILN mission will complete Phase A (KDP-A) by the end of FY 2010. Research Announcement for Lunar Research & Analysis will be released annually, followed by selections and awards. The human space flight review being undertaken during the summer of 2009 may result in changes to the International Lunar Network and robotic lunar exploration program. NASA will notify Congress if there are any changes to the request.

Discovery

Having completed its third fly-by of Mercury, MESSENGER will prepare for Mercury orbit insertion (currently planned for March 2011) while it continues its operations and return of valuable data from the three flybys. The Dawn spacecraft will be cruising from a Mars gravity assist in February 2009 in preparation for its Vesta encounter in 2011. ASPERA-3 will complete collection of data on its extended mission of Mars Express. The M3 instrument will continue to collect its science measurements in 2010 and perform data analysis. The EPOXI mission will be approaching its target, comet Hartley 2, in November 2010. GRAIL will complete its Critical Design Review in first quarter FY 2010 and begin Assembly, Test, and Launch Operations (ATLO) by the end of 2010. With the release of the Announcement of Opportunity (AO) for the next Discovery mission in late CY 2009, concept study selection will be made in 2010.

New Frontiers

Juno will deliver instruments and hardware in preparation for ATLO in FY 2010. The New Horizons mission will continue on its course toward Pluto and its moons, with periodic spacecraft and instrument checkouts as it cruises. Following the Announcement of Opportunity (AO) release in 2009, the New Frontiers 3 concept studies will be selected in FY 2010.

Mars Exploration

The Mars Science Laboratory (MSL) launch date has moved from 2009 to 2011. During FY 2010 MSL will complete remaining hardware and software development, and will start to conduct the Rover System Environmental Test Program. In September 2008, NASA selected the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft as the next Mars Scout mission. By the end of FY 2010 MAVEN will successfully complete the Preliminary Design Review (PDR). ExoMars will have an extended Phase B in FY 2010. Odyssey will be in a new orbit with an expected improved sensitivity to detect minerals on the surface. The Mars Reconnaissance Orbiter (MRO) and (if technically possible) both Spirit and Opportunity rovers (MER) will continue to operate and perform data analysis throughout FY 2010. Concept studies with ESA for partnership missions in 2016/2018 will continue.

Plans for FY 2010

Outer Planets

In February 2009 NASA down-selected the Outer Planets Flagship (OPF) from three science targets to focus on the Europa Jupiter System. In addition to further definition study and technology development efforts for the Europa Jupiter System Mission (EJSM) throughout FY 2010, NASA will also continue to negotiate the details of a potential partnership with the European Space Agency (ESA) and other international partners. NASA Cassini will continue its historic operations and data analysis.

Technology

While there are no major changes to the Technology Program, some funds were added to the program to allow for a completion of the NASA's Evolutionary Xenon Thruster (NEXT) electric propulsion life validation and to start the build for the Advanced Stirling Radioisotope Generator (ARSG) proto-flight unit that would support a flight in the 2013-2014 timeframe. The Technology Program FY 2010 budget will also provide for the Advanced Multi-Mission Operation System (AMMOS) effort in its continuation in the development of multi-mission software tools for spacecraft navigation and mission planning.

Relevance

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

The Planetary Science Program is guided by U.S. National Space Policy and follows NASA's tradition of establishing its priorities through consultation with world-class experts. Planetary Science relies on two advisory bodies for scientific assessments and decadal surveys: the NASA Advisory Council and the National Research Council's (NRC) Space Studies Board. The NRC's decadal surveys help NASA prioritize missions and scientific objectives.

Planetary Science seeks to achieve both near and long-term science goals by studying solar system objects and phenomena in situ. 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 organisms on Earth and about the solar system's planets and moons, they may learn that life has arisen in places beyond Earth.

Robotic explorers gather data to help scientists understand how the planets formed, what triggered different evolutionary paths among planets, and how Earth formed, evolved, and became habitable. To search for evidence of life beyond Earth, scientists use this data to map zones of habitability, study the chemistry of alien worlds, and unveil the processes that lead to conditions necessary for life.

Robotic exploration will generate knowledge about our solar system needed to identify the most promising human exploration missions. This knowledge will also help enable safe human space exploration in the forbidding environments they will encounter.

Relevance to the NASA Mission and Strategic Goals:

Planetary Science supports NASA's achievement of Strategic Plan Sub-goal 3C: Advance scientific knowledge of the origin and history of the solar system, the potential for life elsewhere, and the hazards and resources present as humans explore space.

This effort is comprised of four Outcomes:
3C.1: Progress in learning how the Sun's family of planets and minor bodies originated and evolved.
3C.2: Progress in understanding the processes that determine the history and future of habitability in the solar system, including the origin and evolution of Earth's biosphere and the character and extent of prebiotic chemistry on Mars and other worlds.
3C.3: Progress in identifying and investigating past or present habitable environments on Mars and other worlds, and determining if there is or ever has been life elsewhere in the solar system.
3C.4: Progress in exploring the space environment to discover potential hazards to humans and to search for resources that would enable human presence.

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

Relevance to education and public benefits:

Mission Directorate:	Science
Theme:	Planetary Science

The Planetary Science Theme uses 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. The innovative nature of planetary science projects creates an impetus for new techniques and technologies that later benefit the public. The FIRST Robotics project is a concrete example of the Planetary Science Theme's contribution to education. The Planetary Theme is dedicated to sharing the excitement of discoveries and knowledge generated by space science missions and research, with the public, and thus contributing to educating and inspiring the next generation of scientists and technical workers needed for the 21st century.

Public benefits from Planetary Science include a growing understanding of the solar system and Earth's significance within it. NASA's robotic science missions are paving the way for understanding the origin and evolution of the solar system and working to identify past and present habitable locations. The Theme also enables human space exploration by studying and characterizing alien environments and identifies possible resources that will enable safe and effective human missions to the Moon and beyond.

Performance Achievement Highlights:

After landing on May 25, 2008, Phoenix studied soil with a chemistry laboratory, a microscope, a conductivity probe and cameras. Laboratory tests performed by NASA's Phoenix Mars Lander identified water in a Martian soil sample. The lander's robotic arm delivered the soil sample to an instrument that heats the sample and then identifies the resulting vapors. Besides confirming the 2002 Mars Odyssey finding of water ice near the surface, the science team has tried to determine whether the water ice ever thaws enough to allow biological process and if carbon-containing chemicals and other raw materials necessary for life are present.

Phoenix confirmed that a significant amount of water exists on the surface of arctic Mars, a potential resource for future human exploration. Phoenix also discovered a class of compounds called perchlorates in the soil. Although a few biological forms on Earth use perchlorates as an energy source, they are generally toxic to most life forms if consumed. However, perchlorates are routinely used as the oxidizer in rocket fuel, also a potential resource. The lander's meteorological station documented a temperature range in the Martian polar north of approximately -20 to -115 degrees Fahrenheit during the summer, after which temperatures fell sharply. These conditions pose challenges to human exploration of the Martian polar regions.

The Cassini spacecraft performed a flyby of Saturn's moon Enceladus, coming within 50 kilometers of the moon's surface. During the flyby, the spacecraft collected samples that may provide evidence of a water ocean and organics. The flyby also provided images of the surface that are providing data on the difference between the north and south poles, which is critical to understanding the moon's geological evolution. Furthermore, there is evidence of some complex organic chemicals and several other conditions that scientists believe to be the pre-conditions for life. Future flybys and possibly future missions will provide more pieces in this intriguing puzzle.

On the first of its passes by Mercury, the MESSENGER spacecraft provided new insights into the origin and evolution of the solar system's smallest planet. MESSENGER confirmed that Mercury has a dipolar internal magnetic field, created an inventory of the heavy ions in the planet's magnetosphere, and detected two current sheet boundaries that may indicate a planetary ion boundary layer.

In 2008, NASA Selected GRAIL, a lunar gravity mapping mission, as the Discovery 11 mission and MAVEN, a Mars aeronomy mission, as the Mars Scout 2nd mission. The Juno mission, which will conduct an in-depth study of Jupiter, completed its Preliminary Design Review and moved into implementation to support an August 2011 launch.

The Lunar Science Program's LADEE lunar dust mission completed studies and moved into formulation phase. The Program also established the NASA Lunar Science Institute.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NASA Advisory Council	02/2007	Reviews science and program implementation strategies and relevancies to the NASA strategies and goals. Findings from the 2007 review included, NASA has made significant progress toward implementing the recommendations of the NRC's decadal survey and Mars Architecture report. NASA's current planetary exploration program is highly productive, carrying out exciting missions and making fundamental discoveries.	12/2010
Relevance	National Research Council	12/2003	Decadal Survey of Planetary Science priorities/Published Decadal Report entitled "New Frontiers and the Solar System: An Integrated Exploration Strategy". Work on the next Decadal Survey began in 2008.	09/2013

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Planetary Science Research

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	183.1	162.1	161.7	193.5	240.2	232.6	254.2
Planetary Science Research and Analysis	133.6	135.0	135.1	144.4	153.2	156.9	160.7
Other Missions and Data Analysis	18.6	19.5	21.4	22.2	22.3	22.7	29.3
Education and Directorate Management	27.7	3.9	1.4	23.1	60.7	49.0	60.1
Near Earth Object Observations	3.3	3.7	3.8	3.8	3.9	4.0	4.1
FY 2009 President's Budget Request	245.4	274.5	319.6	359.5	377.1	386.6	--
Planetary Science Research and Analysis	127.8	142.4	145.1	150.4	155.2	159.0	--
Other Missions and Analysis	41.8	124.5	143.4	162.2	172.3	174.6	--
Education and Directorate Management	72.4	3.9	27.4	43.1	45.7	49.0	--
Near Earth Object Observations	3.4	3.7	3.8	3.8	3.9	4.0	--
Changes from FY 2009 Request	-62.3	-112.4	-157.9	-166.0	-137.0	-154.0	--

Program Overview

The Planetary Science Research Program supports the development of 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. These capabilities allow Planetary Science to answer specific questions and develop an increased understanding of the origin and evolution of the solar system. This program represents an essential complement to flight missions, providing the scientific research and the theoretical foundation to allow the nation to fully utilize the unique data sets returned from the missions exploring the solar system. It is also NASA's primary interface with university faculty and graduate students in this field as well as the research community in general. The Research Program achieves this goal by supporting research grants which are solicited annually and subjected to a careful peer review before being awarded.

The changes in the table above do not reflect a reduction, but instead reflect a transfer of Lunar Science Research (carried within Planetary Science Research in the FY 2009 Request) to the new Lunar Quest Program in the FY 2010 Request.

For further information see: http://nasascience.nasa.gov/planetary-science

Plans For FY 2010

Release Research Announcements soliciting Research and Analysis proposals and make selections.

Continue planetary science data archiving and releasing of this data to the science community in a timely manner for further scientific analysis.

Continue curation and distribution of solar system samples (Astromaterials) returned by NASA planetary missions such as Stardust.

Support the Rosetta fly-by of Asteroid Lutetia (November 2010).

Continue to provide for Hayabusa (MUSES-C) navigation and Deep Space Network Tracking and coordinating Science Analysis to support an Earth Return in 2010.

Continue to support Near Earth Objects Observations (NEOO) to detect impact hazards to the Earth.

Project Descriptions and Explanation of Changes

Planetary Science Research and Analysis

The scope of Research and Analysis (R&A) is wide because the effort must provide new theories and instrumentation that enable the next generation of flight missions. R&A also provides the foundation for the formulation of new scientific questions and strategies. Discoveries and concepts developed in the R&A Project are the genesis of scientific priorities, missions, instrumentation, and investigations. R&A supports research tasks in areas such as: astrobiology and cosmochemistry; the origins and evolution of planetary systems; and the atmospheres, geology, and chemistry of the solar system's planets (other than Earth). R&A provides for instrument and measurement concepts, and supports the initial definition and development of instruments for future Discovery, New Frontiers, or Mars missions. A new and fully competed call for missions' studies will identify a range of outer planets science targets and mission options that could be achieved at various budget levels, creating a "menu" of mission options that NASA could pursue in the future. Lunar science research has been moved to the Lunar Quest Program.

Other Missions and Data Analysis

Rosetta, a European Space Agency/NASA comet rendezvous mission in operations phase, launched in March 2004 and will arrive at comet Churyumov-Gerasimenko in 2014. The prime scientific objective of the Rosetta mission is to study the origin of comets, the relationship between cometary and interstellar material, and the implications of comets with regard to the origin of the solar system. The Rosetta spacecraft will be the first to undertake the long-term exploration of a comet at close quarters. It comprises a large orbiter, which is designed to operate for a decade at large distances from the Sun, and a small lander. Each of these carries a large complement of scientific experiments designed to complete the most detailed study of a comet ever attempted. Rosetta will allow scientists to look back 4600 million years to an epoch when no planets existed and only a vast swarm of asteroids and comets surrounded the Sun.

Hayabusa (MUSES-C), in operations phase, is a joint Japanese/NASA mission to rendezvous with near-Earth asteroid and return samples. The spacecraft launched in May of 2003 and landed on the Asteroid Itokawa in September 2005. In April 2007, the spacecraft began its return to Earth bringing with it an asteroid sample. Hayabusa will arrive at Earth in 2010. Hayabusa observed Itokawa's shape, geographical features, reflectance, mineral composite, and gravity from an altitude of 3 to 20 km, and clarified the Itokawa's structure as a "pile of rubble." Science published seven Hayabusa-related essays, the first time for the magazine to feature a Japanese asteroid probe project. The Hayabusa project also received a "Space Pioneer Award" from the National Space Society of the United States at the International Space Development conference held in Los Angeles in May.

The Planetary Data Systems (PDS) and Astromaterials Curation Projects provide funds for data archives, sample-holding facilities, and analysis tools needed to perform research. PDS is the active data archive for NASA's Planetary Science Theme. The Astromaterials Curation Facility, at Johnson Space Center, provides services for all returned planetary materials that do not require planetary protection laboratories.

Education and Directorate Management

The Education and Directorate Management projects include Science Mission Directorate-wide management reserve. It is used to support unforeseen administrative and programmatic requirements that cannot and/or should not be funded by other programs and projects.

For Inspiration and Recognition of Science and Technology (FIRST) is a non-profit organization dedicated to increasing interest in science, technology, engineering and mathematics among youth in the United States. There are annual activities and events to expose students to challenging applications of engineering and science. The FIRST Robotics competition consists of national contests in which high school students team with engineers from government, industry, and universities to get hands-on experience and mentoring from engineering and technical professionals.

Near Earth Object Observations

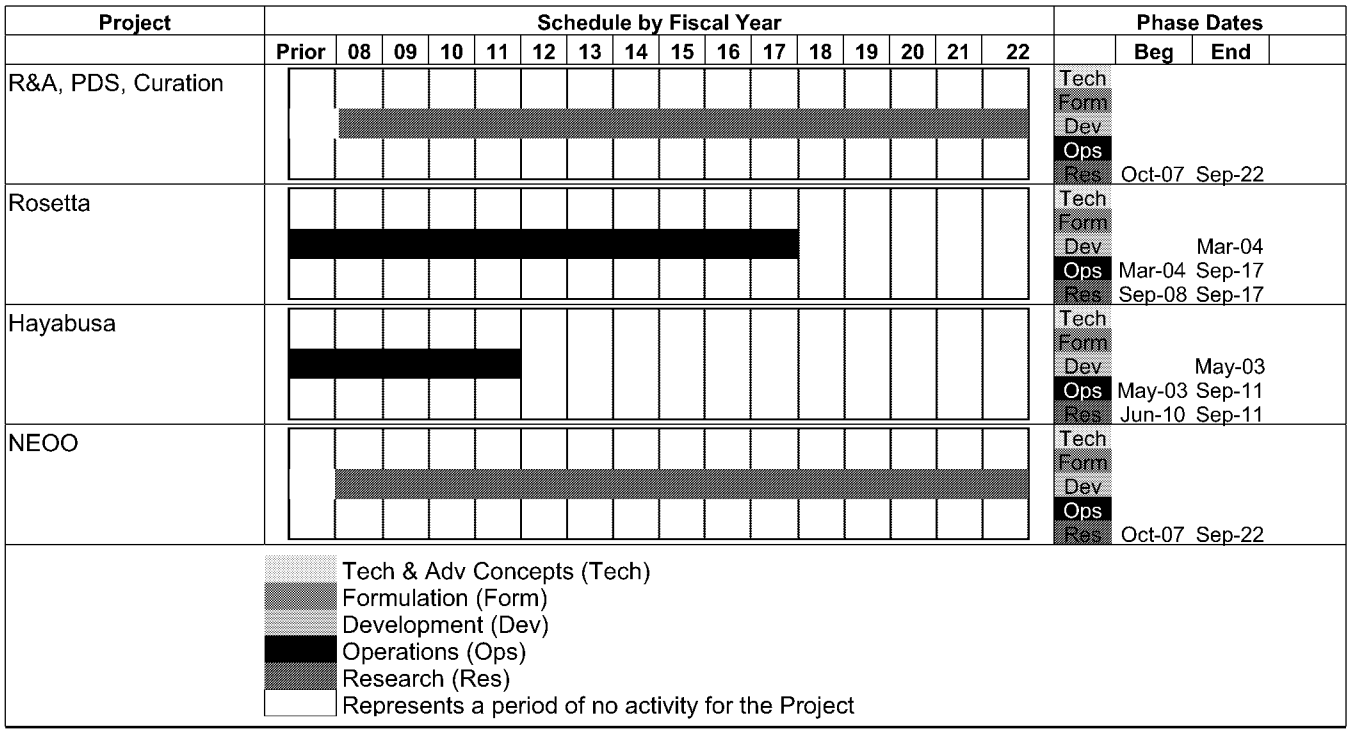
The Near Earth Object Observations (NEOO) was transfered from the Earth Science Division beginning in FY 2010. Its objective is to detect and track at least 90 percent of the Near Earth Objects, asteroids, and comets that come within 1.3 Astronomical Units of the Sun, and to find those which have any potential to collide with Earth and do significant damage at the surface. A network of existing ground-based telescopes and modifications to existing space-based sensors, and supporting data processing and analysis infrastructure, will be funded to achieve this objective.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Release of Research Announcements soliciting R&A proposals (annual selections)	Research & Analysis (R&A)	Same
Meeting commitments to the International Partners as agreed to in the MOU.	Rosetta and Hayabusa	Same
Archive and release mission data to the science community within 6 months of downlink.	Planetary Data System (PDS)	Same
Store new samples of Astromaterials and distribute them as requests are approved by CAPTEM.	Astromaterials Curations	Same
Continue search for hazardous NEOs, asteroids, and comets down to 140 meters in size that may pose an impact threat.	NEOO	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Planetary Science Research

Implementation Schedule



Program Management

NASA HQ is responsible for R&A; JPL is responsible for Rosetta and Hayabusa operations and the NEOO Program Office; GSFC is responsible for PDS project management; and JSC is responsible for Astromaterials Curation project management Program Office.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Research & Analysis	HQ	Multiple (NASA Centers, Universities, industries, etc.)	None
Rosetta	JPL	JPL	The European Space Agency (ESA) built the spacecraft, provided the launch vehicle, and operates the spacecraft.
Hayabusa (Muses -C)	JPL	JPL	Japan Aerospace Exploration Agency (JAXA) responsibilities include the spacecraft, launch vehicle, and operations.
Planetary Data System (PDS)	GSFC	JPL and other Discipline Nodes	None
Astromaterials Curation	JSC	JSC	NSF and Smithsonian Institution for Antarctic meteorites
NEOO	JPL	JPL	None

Acquisition Strategy

The R&A FY 2010 budget will fund competitively selected activities from the ROSES-07 (Research Opportunities in Space and Earth Science) Omnibus NRA. All major acquisitions for Rosetta, Hayabusa, Planetary Data System (PDS), Astromaterial Curation, and Near Earth Object Observation are in place. The following institutions operate the PDS nodes: Atmospheres Node (NMSU); Engineering Node (JPL); Geosciences Node (Wash U St. Louis); HiRISE Data Node (UAZ); Human Interface Design (ARC); Imaging Node (USGS Flagstaff); Navigation Ancillary Information Facility (NAIF at JPL); Planetary Plasma Interactions Node (UCLA); Radio Science (SETI); Rings Node (SETI); Small Bodies Node (U of MD); JPL, and ARC.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Panel of scientists	10/2008	Curation and Analysis Planning Team for Extraterrestrial Materials (CAPTEM) reviews ongoing curation activities and future plans. Curation of Genesis, Stardust, and Apollo lunar samples are on track and meeting distribution requests. The Curation Project is performing well overall. They reviewed and approved numerous samples for distribution to scientists and reviewed plans for the upgrade of JSC curation facilities and efforts to work with Constellation on curation of samples on the Moon.	03/2009

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**41.3**	**105.0**	**103.6**	**142.6**	**138.6**	**145.5**	**118.7**
Lunar Science	**36.2**	**64.8**	**33.3**	**52.4**	**58.5**	**64.3**	**39.4**
Lunar Atmosphere and Dust Environment Explorer	**5.1**	**30.2**	**66.5**	**73.9**	**31.1**	**0.0**	**0.0**
International Lunar Network	**0.0**	**10.0**	**3.7**	**16.3**	**48.9**	**81.2**	**79.3**
Changes from FY 2009 Request	**41.3**	**105.0**	**103.6**	**142.6**	**138.6**	**145.5**	**--**

Note: The human space flight review being undertaken during the summer of 2009 may result in changes to the robotic lunar exploration program. NASA will notify Congress if there are any changes to the request.

Program Overview

The Lunar Quest Program (LQP) goal is to conduct science exploration of the Moon through research and analysis, and through the development of a series of small-medium satellite and surface missions. The LQP answers the National Research Council report, "The Scientific Context for Exploration of the Moon" (SCEM) and fits within NASA's Space Exploration Policy to scientifically explore our Solar System. The LQP complements other lunar missions sponsored by NASA and international agencies.

The goal of the LQP is to provide small robotic lunar science investigations and lunar research and analysis addressing prioritized science objectives. LQP objectives include:
- Re-establish lunar science and a lunar science community;
- Facilitate the application of enhancing or enabling technologies to support flight missions; and
- Enhance science opportunities in the implementation of NASA's lunar exploration goals.

In order to achieve LPQ goals and objectives, the program currently exists as a loosely coupled, multi -element science program with both flight and research opportunities. The projects will be independent but will also have interrelated objectives and a common management and funding structure. The LQP program element includes two classes of flight opportunities for lunar science investigations: small robotic science spacecraft or landers and a Mission of Opportunity (MoO). The Lunar Atmosphere and Dust Environment Explorer (LADEE) and the International Lunar Network (ILN) are two small robotic orbiter and lander missions currently under formulation as part of the LQP. The LQP also includes a Lunar Science Research and Analysis (R&A) element that will enhance participation and collaboration within the lunar science community. This science participation will provide near-term activity stimulating and reinvigorating the broad scientific community enticing international collaboration for mutual leverage in accomplishing lunar goals and objectives.

In the FY 2009 Request, funding for these efforts was carried under the Planetary Science Research Program. The human space flight review being undertaken during the summer of 2009 may result in changes to the robotic lunar exploration program. NASA will notify Congress if there are any changes to the request.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

Plans For FY 2010

Confirm LADEE for Implementation Phase (KDP-C).

Complete ILN Phase A (KDP-A) by the end of CY 2010.

Release Research Announcement soliciting Research & Analysis proposals and make selections.
The human space flight review being undertaken during the summer of 2009 may result in changes to the robotic lunar exploration program. NASA will notify Congress if there are any changes to the request.

Project Descriptions and Explanation of Changes

Lunar Science

Lunar Research & Analysis (R&A) will enhance participation and collaboration within the lunar science community. It is composed of competed research and analysis opportunities such as: National Lunar Science Institute (NLSI) - a virtual institute of geographically dispersed researchers and institutions, directed by the Ames Research Center for management and implementation; Lunar Advanced Science and Exploration Research (LASER) - a lunar-only element in the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement (NRA); Lunar Data Competed Studies - research and analysis of existing and new lunar science data procured under other ROSES elements.

After one year of operation to accomplish Exploration objectives, Lunar Reconnaissance Orbiter (LRO) will be transitioned to SMD/Planetary Science in August 2010 to start a two-year lunar science mission as identified by the NRC (Decadal Survey and Scientific Context for Exploration of the Moon [SCEM] report). The LRO Science Mission will give the scientific community a unique opportunity to concentrate the capabilities of the 7 LRO instruments on focused lunar science investigations identified from the data obtained in the "mapping" mission. The focused investigations will allow us to quantify our understanding of the origin and evolution of the Moon.

Lunar Program Management provides management and oversight of the Lunar Quest selected flight missions. This line also provides for independent panel reviews and selections process efforts.

Lunar Atmosphere and Dust Environment Explorer (LADEE)

Currently in Phase A, LADEE, the first LQP mission, is a cooperative effort between Ames Research Center (ARC) and Goddard Space Flight Center (GSFC). The LADEE mission objective is to address high priority science goals as identified by the NRC report, to determine the global density, composition, and time variability of the fragile lunar atmosphere before it is further perturbed by future human activity. LADEE's measurements will also determine the size, charge, and spatial distribution of electrostatically transported dust grains and assess their likely effects on lunar exploration and lunar-based astronomy. Additionally, LADEE will carry the optical laser communications package to be provided by the Space Operations Mission Directorate (SOMD). The optical laser will technically demonstrate high bandwidth communication from the Moon. The orbiter is currently planned for a launch in May 2012. The nominal science mission is 100 days in length, with an option for an additional year of laser communications demonstrations.

International Lunar Network (ILN)

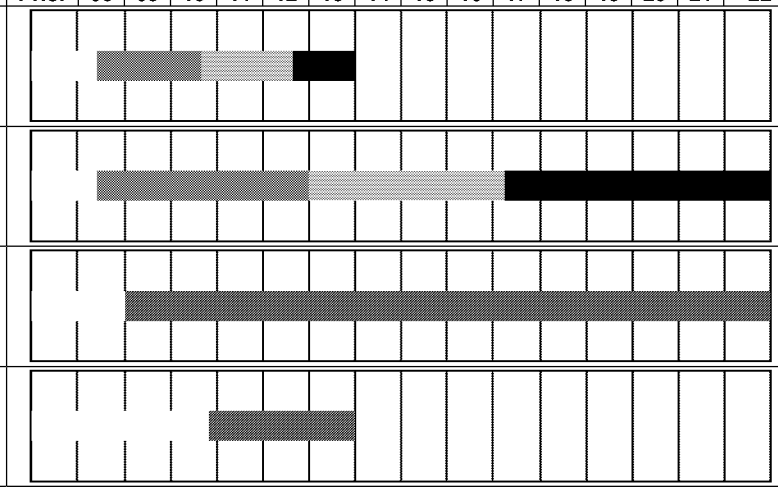
Currently in Pre-Phase A, the ILN Anchor Nodes will be the backbone of a lunar geophysical network, providing global coverage by involving US and international landed missions as individual stations working together - the first US robotic lunar landers since 1968! The ILN Anchor Nodes project is a cooperative effort between Marshall Space Flight Center (MSFC) and the Johns Hopkins University Applied Physics Laboratory (APL). The ILN mission will deliver and will operate geophysical instrument packages at different places on the lunar surface. The nominal mission length is for six years concurrent of surface operations, including operating the instruments through lunar night. The human space flight review being undertaken during the summer of 2009 may result in changes to the International Lunar Network and the robotic lunar exploration program. NASA will notify Congress if there are any changes to the request.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Conduct scientific investigations to achieve SMD lunar science goals and objectives in the "Scientific Context for Exploration of the Moon" (SCEM, 2007).	Lunar Quest Program	New Program

Implementation Schedule



Program Management

Scientific mission priorities and assignment responsibilities reside with SMD. MSFC has Lunar Quest program management responsibility.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
LADEE	MSFC	ARC, GSFC, KSC	N/A
International Lunar Network (ILN)	MSFC	MSFC, APL, KSC, GRC, DOE	TBD
Research & Analysis	HQ	ARC, GSFC, MSFC, JPL, JSC	N/A

Acquisition Strategy

The LQP acquisition strategy is to direct development of flight projects including the spacecraft bus to NASA centers, competitively select instruments and science team participation through the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement (NRA) and the Stand Alone Missions of Opportunity (SALMON) AO processes.

Major acquisitions for the LADEE (ARC and GSFC) and ILN (MSFC) projects are in place. NASA has selected ARC and GSFC to provide the spacecraft for LADEE, and MSFC to provide the spacecraft for ILN. Three science instruments have been selected for LADEE (Neutral Mass Spectrometer [NMS], UV Spectrometer [UVS], and Lunar Dust EXperiment [LDEX], and an optical communication package. The NMS instrument will be provided by GSFC, ARC will provide UVS, University of Colorado/LASP will provide LDEX, and SOMD selected MIT/LL and GSFC to provide its LLCD contribution.

Science instruments and research and analysis of existing and new lunar science data are to be procured under the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement (NRA). Mission of opportunity (MO) are to be selected via the Stand Alone Missions of Opportunity (SALMON) AO.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	NA	Standing Review Board (SRB) will be assigned to first perform a Program Acceptance Review (PAR) assessing the Program's readiness to enter implementation. Following approval to enter implementation, the SRB will thereafter conduct biannual Program Implementation Reviews (PIRs) throughout implementation to assure the program is operating according to the program plan and that it is successfully meeting program objectives.	04/2009

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Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	136.4	247.0	213.2	234.6	256.8	256.5	264.3
Gravity Recovery and Interior Laboratory (GRAIL)	67.0	122.4	124.1	104.8	41.4	4.7	0.0
Other Missions and Data Analysis	69.3	124.6	89.1	129.9	215.4	251.8	264.3
FY 2009 President's Budget Request	153.0	247.0	258.3	256.0	326.1	140.5	--
Gravity Recovery and Interior Laboratory (GRAIL)	0.0	122.4	122.8	113.1	24.9	5.7	--
Other Missions and Data Analysis	153.0	124.6	135.5	143.0	301.3	134.8	--
Changes from FY 2009 Request	-16.6	0.0	-45.1	-21.4	-69.3	116.0	--

Program Overview

Robotic space exploration holds tremendous opportunity for exploration and discovery. Even with the vast amount of knowledge gained since exploration of the solar system began, there are many unanswered questions about the origin and evolution of our own solar system. NASA's Discovery Program provides the opportunity to utilize innovative missions to uncover the mysteries of the solar system. It provides highly-focused planetary science investigations designed to increase our understanding of the solar system and its evolution. The Discovery Program offers the scientific community the opportunity to assemble and lead cross-functional teams to design and implement exciting science investigations that complement NASA's larger planetary science missions.

All completed Discovery missions (NEAR, Mars Pathfinder, Lunar Prospector, Deep Impact, Stardust, and Genesis) have achieved groundbreaking science, with each taking a unique approach to space exploration. Current Discovery missions include: ASPERA-3, MESSENGER, Dawn, Moon Mineralogy Mapper (M3), EPOXI, StardustNExT, and the Gravity Recovery and Interior Laboratory (GRAIL). Additional details on the GRAIL mission are contained in the GRAIL "Project in Development" pages.

For more information regarding the Discovery Program, see http:/discovery.nasa.gov.

Plans For FY 2010

The MESSENGER spacecraft will have completed its third fly-by of Mercury in late FY 2009 (9/2009) and will begin preparations for its Mercury orbit insertion in 2011. The Dawn spacecraft will be cruising from a Mars gravity assist in February 2009 in preparation for its Vesta encounter in 2011. ASPERA-3 will complete collection of data on its extended mission of Mars Express. The Moon Mineralology Mapper (M3) instrument, as a part of the ISRO's Chandrayaan-1 payload, will continue to collect its science measurements and perform data analysis. The EPOXI mission will be approaching and will begin preparation for the encounter of its target, comet Hartley 2, in November 2010. GRAIL will complete its Critical Design Review in the first quarter of FY 2010 and plans to begin Assembly, Test, and Launch Operations (ATLO) by the end of 2010. The next Announcement of Opportunity (AO) for a new Discovery mission will be released in CY 2009 followed by a concept study and selection in 2010.

Project Descriptions and Explanation of Changes

GRAIL

GRAIL is in its development phase. GRAIL will perform high-quality gravity field mapping of the Moon to determine its interior structure. GRAIL will provide the most accurate global gravity field to date for any planet, including Earth. GRAIL will enable the public to directly interact with observations through cameras on each satellite dedicated to public outreach and education. GRAIL was selected in December 2007 and given approval to proceed into its Development Phase (Phase C) in January 28, 2009. GRAIL is currently scheduled to launch in September 2011. Additional detail can be found in the GRAIL section of this document.

Other Missions and Data Analysis

The Dawn mission while in its operations phase, has begun a journey to the two largest and most massive asteroids in our solar system, Vesta and Ceres. Vesta's physical characteristics reflect those of the inner planets, whereas Ceres' are more like the icy moons of the outer planets. By studying these contrasts and comparing these two minor planets, scientists will develop an understanding of the transition from the rocky inner regions to the icy outer regions of the Solar System. The Dawn mission marks the first time a spacecraft will orbit a body in the main asteroid belt and the first time a spacecraft will orbit two targets, enabling a detailed and intensive study of both. Dawn launched in September 2007. After a Mars gravity assist in February 2009, the Dawn spacecraft will encounter and orbit Vesta in 2011, then travel an additional three years to reach and orbit Ceres.

MESSENGER, a mission to Mercury, is in its operations phase and launched on August 3, 2004. It has collected the first images toward providing coverage of the entire planet and collected detailed information on the composition and structure of Mercury's crust, its geologic history, the nature of its thin atmosphere and active magnetosphere, and the makeup of its core and polar materials. MESSENGER is the first deep-space mission to use a circularly polarized phased-array antenna - the antenna "points" electronically, which allows MESSENGER to return a large amount of data without using a deployable, gimbaled antenna (such as the one that failed to deploy on the Galileo mission). MESSENGER carries seven scientific instruments and a radio science experiment to accomplish an ambitious objective: return the first data from Mercury orbit. The miniaturized payload ' designed to work in the extreme environment near the Sun ' will image all of Mercury for the first time, as well as gather data on the composition and structure of Mercury's crust, its geologic history, the nature of its active agnetosphere and thin atmosphere, and the makeup of its core and the materials near its poles.

As a result of three 2006 Discovery missions of opportunity being selected on June 19, 2007, Deep Impact and Stardust are both in extended operations phase. The EPOCh mission will use the high-resolution camera on the Deep Impact spacecraft to search for Earth-sized planets around other stars. The DIXI mission will investigate comets using the existing Deep Impact spacecraft for an extended flyby mission to a second comet to take pictures of its nucleus and increase our understanding of the diversity of comets. These two missions were combined into the joint mission EPOXI. The Stardust NExT will use the existing Stardust spacecraft for a flyby of comet Tempel 1. Since the Deep Impact mission visited Tempel 1 in 2005, the comet has made another close approach to the sun, possibly eroding its surface. This flyby is to look for surface changes to Tempel 1 since 2005.

ASPERA-3, a Mission of Opportunity, is in its operational phase. It is one of seven instruments aboard the European Space Agency's Mars Express spacecraft in orbit around Mars, with a goal to study the interaction of the solar wind and Martian atmosphere. The measurements taken by this instrument will help answer the question of how strongly the interplanetary plasma and electromagnetic fields affect the Martian atmosphere.

The M3 instrument, in its operation phase, is part of the scientific payload for ISRO's Chandrayaan-1 mission which launched October 2008 from India. Primary objectives of M3 are to assess the mineral resources of the Moon, and characterize and map the composition of the surface at high spatial resolution. The M3 payload has reached its final polar orbit of the Moon and will operate during the next two years with active data collection concentrated into four 2-month periods. While Global mapping has top priority, additional targeted mapping will occur at M3's highest resolution.

Other Missions & Data Analysis (Continued)

The Discovery Research line provides funding for: Discovery Data Analysis; Sample Return Laboratory Instruments (SRLI) which supports development of new instruments for use in terrestrial laboratories to analyze samples returned from NASA Planetary Science missions; Data Analysis Program (DAP); and participating scientists for the MESSENGER mission. As stated in the ROSES NRA, the DAP is "...to enhance the scientific return of the completed Discovery missions by broadening the science participation in the analysis of data collected and samples returned ...." Specifically, the DAP allows scientists not previously associated with Discovery missions an opportunity to perform data analysis of the data archived in the Planetary Data System or samples (such as those from Stardust) stored at the JSC curation facility, which is also funded by this project. Data access through the Discovery Research project allows a much broader, and perhaps more objective analysis of the data and samples, and also allows research to continue for many years after the mission has been completed. Areas for additional data analyses are proposed by scientists throughout the US planetary community and are competitively selected with major input from science community peer review.

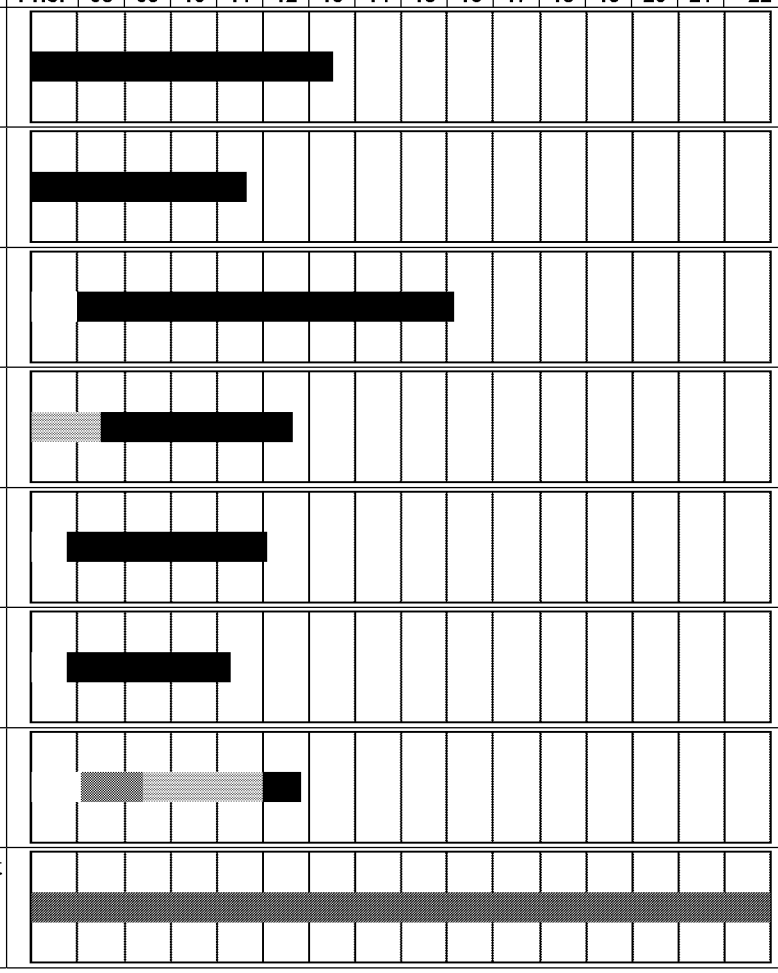
The Discovery Future line provides funds for future Discovery flight missions to be selected via a competitive Announcement of Opportunity (AO) process. Discovery Program Management provides for the management of the Discovery selected flight missions. This line also provides for the development of Announcements of Opportunity (AOs), and supports independent panel reviews and selections process.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Launch an average of one mission per 24 months .	Discovery Program	Same
Complete current prime and funded extended operating missions.	Dawn, MESSENGER, ASPERA-3, EPOXI and StardustNExT	Same
Complete design and begin spacecraft development and assembly	GRAIL	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Implementation Schedule



Project	Phase	Beg	End
MESSENGER	Tech		
	Form	Jul-99	Jun-01
	Dev	Jun-01	Aug-04
	Ops	Aug-04	Mar-13
	Res		
ASPERA-3	Tech		
	Form		
	Dev	Sep-00	Jun-03
	Ops	Jun-03	May-11
	Res		
Dawn	Tech		
	Form	Dec-01	
	Dev	Feb-04	Sep-07
	Ops	Sep-07	Nov-15
	Res		
Moon Mineralogy Mapper (M3)	Tech		
	Form	Mar-05	Feb-06
	Dev	Mar-06	Mar-08
	Ops	Mar-08	Jun-12
	Res		
EPOXI	Tech		
	Form		
	Dev		
	Ops	Jun-07	Oct-11
	Res		
Stardust NExT	Tech		
	Form		
	Dev		
	Ops	Jun-07	Feb-11
	Res		
GRAIL	Tech		
	Form	Oct-07	Mar-09
	Dev	Mar-09	Sep-11
	Ops	Oct-11	Jul-12
	Res		
Discovery Management	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-99	Sep-22

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

Program Management

MSFC is responsible for Discovery program management. Scientific mission priorities and assignment of responsibilities reside with the Science Mission Directorate.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
MESSENGER	MSFC	GSFC, JPL	None
ASPERA-3	MSFC		Sweden; European Space Agency (ESA).
Dawn	MSFC	JPL	German Aerospace Center (DLR); Los Alamos National Labs (LANL); Italian Space Agency; and Max-Planck.
M3	MSFC	JPL	ISRO spacecraft provider. USGS.
EPOXI	MSFC	JPL	Max-Planck-Institute in Garsching, Germany
Stardust-NExT (Stardust-New Exploration of Tempel)	MSFC	JPL	None
GRAIL	MSFC	GSFC, JPL, KSC	None

Acquisition Strategy

With the exception of future NASA Announcements of Opportunity, all major acquisitions are in place.

Southwest Research Institute employs the Principal Investigator and Lead Scientist for ASPERA-3.

The University of California at Los Angeles sponsors the Principal Investigator and Lead Scientist for the Dawn mission.

Brown University sponsors the Principal Investigator and Lead Scientist for M3. SAIC, University of Hawaii, and University of Tennessee are also participants.

The Department of Terrestrial Magnetism at the Carnegie Institution of Washington employs the Principal Investigator and Lead Scientist for MESSENGER.

The University of Maryland employs the Principal Investigator for the EPOXI Mission of Opportunity, the combined EPOCh and DIXI missions.

Cornell University employs the Principal Investigator for the Stardust New Exploration of Tempel 1 (NExT) Mission of Opportunity.

The Massachusetts Institute of Technology (MIT) employs the Principal Investigator and leads the GRAIL mission.

The Discovery Program solicits proposals for full planetary missions and missions of opportunity. The proposals are put together by teams led by a PI which may include firms, small businesses, government and universities. The initial phase of each competitive selection is a concept study, and several missions and missions of opportunity are generally selected for this phase. At the completion of the study phase, one or more concepts may be selected for development, based on their continued scientific merit, technical, management and cost viability, and the availability of funding.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2008	Verified compliance with Agency requirements for program implementation and alignment with Agency strategic goals and objectives. The Discovery Program provides effective technical and schedule analysis support to the projects and continues to actively use risk-based insight as part of its oversight of the projects. The AO process has proven to be a well-defined, disciplined process that is viewed by the science community as fair and effective.	10/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**1.2**	**67.0**	**122.4**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**0.0**	**465.6**
Formulation	1.2	27.0	22.3	0.0	0.0	0.0	0.0	0.0	0.0	50.5
Development / Implementation	0.0	40.0	100.1	124.1	104.5	27.7	0.0	0.0	0.0	396.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.3	13.7	4.7	0.0	0.0	18.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**1.2**	**0.0**	**122.4**	**122.8**	**113.1**	**24.9**	**5.7**	**--**	**0.0**	**390.0**
Formulation	1.2	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	1.2
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	0.0	0.0	122.4	122.8	113.1	24.9	5.7	--	0.0	388.8
Changes from FY 2009 Request	**0.0**	**67.0**	**0.0**	**1.3**	**-8.3**	**16.5**	**-0.9**	**--**	**0.0**	**75.6**
Formulation	0.0	27.0	22.3	0.0	0.0	0.0	0.0	--	0.0	49.3
Development / Implementation	0.0	40.0	100.1	124.1	104.5	27.7	0.0	--	0.0	396.4
Operations / Close-out	0.0	0.0	0.0	0.0	0.3	13.7	4.7	--	0.0	18.7
Other	0.0	0.0	-122.4	-122.8	-113.1	-24.9	-5.6	--	0.0	-388.8

Note: The FY 2010 LCC number in the table above is understated by $30.6M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost will be $496.2M, and the estimated development cost will be $427.0M.

Explanation of Project Changes

GRAIL was confirmed to proceed into implementation phase (KDP-C or Phase C/D) on January 28, 2009. This budget reflects GRAIL approved baseline for schedule, development cost, and life-cycle-cost (LCC) with the 70% cost confidence level.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

Project Purpose

GRAIL was selected in December 2007 under the 2006 Discovery Announcement of Opportunity. The overarching scientific goal of the GRAIL mission is to determine the structure of the lunar interior from crust to core. The GRAIL mission will also advance our understanding of the thermal evolution of the Moon and extend our knowledge gained from the Moon to the other terrestrial-type planets.
GRAIL will conduct six lunar science experiments: map the structure of the crust and lithosphere; study the moon's asymmetric thermal evolution; determine the subsurface structure of impact basins and the origin and of masons (i.e., high-gravity areas); study the temporal evolution of crustal brecciation and magmatism; study affect on the structure of the deep lunar interior from lunar tides; and understand the size of the possible lunar inner core.

Project Parameters

GRAIL will achieve its science objectives by placing twin spacecraft in a low altitude (50 km), and nearly circular, polar orbit. The two spacecraft will perform high-precision range-rate measurements between them. Analysis of changes in the spacecraft-to-spacecraft range-rate data caused by gravitational differences will provide direct and high-precision measurements of the lunar gravity. GRAIL will ultimately provide a global, high-accuracy (<10 mGal), high-resolution (30 km) gravity map of the moon. The instrument is based on the successful Earth orbiting Gravity Recovery and Climate Experiment (GRACE) mission.

Project Commitments

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Flight System	Lockheed Martin	2 spacecraft with s/c separation of 175-225 km, conducting 90-day science phase	Same	Same
Lunar Gravity Ranging System	JPL	Ka-band ranging system determines the precise instantaneous relative range-rate of the two s/c	Same	Same
E/PO MoonKam	Sally Ride Science (SRS)	Take images of the moon, the data will enrich the middle school space science curriculum	Same	Same
Launch Vehicle	ULA	CLIN23 - Delta II Heavy	Same	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

Schedule Commitments

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
Development (Phase C/D or KDP-C)	January 28, 2009	Same	Same
Critical Design Review (CDR)	November 2009	Same	Same
System Integration Review (formerly ATLO)	July 2010	Same	Same
Launch Readiness Review	September 2011	Same	Same
End of Prime Mission	June 2012	same	same

Development Cost and Schedule Summary

GRAIL was confirmed to proceed into implementation phase (KDP-C or Phase C/D) on January 28, 2009. This budget reflects the approved GRAIL Project baseline for schedule, development cost, and life-cycle-cost (LCC).

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Gravity Recovery and Interior Laboratory	2009	427.0	2009	427.0	0	Launch Readiness	9/8/2011	9/8/2011	0

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**427.0**	**427.0**	**0.0**
Payload	18.1	18.1	0.0
Spacecraft	133.3	133.3	0.0
Ground System	12.3	12.3	0.0
Science	10.8	10.8	0.0
Launch Vehicle	152.8	152.8	0.0
Other	99.7	99.7	0.0

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery
Project In Development:	Gravity Recovery and Interior Laboratory

Project Management

The Gravity Recovery and Interior Laboratory Project is part of the Discovery Program managed by Marshall Space Flight Center. The Principal Investigator from Massachusetts Institute of Technology has delegated day-to-day project management to JPL.

Acquisition Strategy

GRAIL was selected competitively in December 13, 2007 under a Discovery Program Announcement of Opportunity (AO-NNH06ZDA001O).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2008	Assess cost, schedule, and risk status of project. Findings for the review showed that cost and schedule for the 2011 launch are consistent with the project's plans.	10/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Vehicle	One significant risk is the continued availability of Delta II line and launch pad at affordable costs	ULA is committed to ensuring that the Delta II will be ready and continued insight/oversight with KSC.
Spacecraft & Reaction Wheel	Both GRAIL spacecraft are largely single string, and the light weight Reaction Wheel (RW) is a new development.	The single string risks are mitigated by use of proven designs, high reliability parts, and additional testing of critical systems, consistent with the cost and schedule constraints of the project. If the light weight reaction wheel development falls behind schedule, the project will revert back to an existing RW.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	115.1	263.9	264.1	239.9	294.2	239.8	249.6
Juno	95.0	245.0	237.2	174.2	71.4	17.8	18.1
Other Missions and Data Analysis	20.2	19.0	26.9	65.7	222.8	222.0	231.5
FY 2009 President's Budget Request	132.2	263.9	250.3	232.3	227.7	236.9	--
Juno	108.3	245.0	225.2	168.0	14.4	17.8	--
Other Missions and Data Analysis	23.9	19.0	25.1	64.3	213.3	219.1	--
Changes from FY 2009 Request	-17.1	0.0	13.8	7.5	66.5	2.9	--

Program Overview

The New Frontiers Program, comprised of medium-sized to large-sized missions, constitutes a critical element of NASA's solar system exploration capability. Proposed science targets for the New Frontiers Program have included Pluto and the Kuiper Belt, Jupiter, Venus, and sample returns from Earth's Moon and a comet nucleus. The program accomplishes high-quality planetary science investigations using efficient management approaches. The program's prime objectives are to enhance our understanding of the solar system as it is today, and of the solar system's formation and evolution.

New Horizons and Juno are New Frontiers selected flight missions. New Horizons will conduct reconnaissance of Pluto and its moon Charon. Juno's overarching scientific goal is to understand the origin and evolution of Jupiter.

For more information, see http://newfrontiers.msfc.nasa.gov.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

Plans For FY 2010

The New Frontiers Program is built around a core of high-priority science missions identified by the science community by the National Academy of Sciences. The program allows NASA to solicit competitive innovative proposals from scientists for large new planetary missions that promise the Nation a high return in knowledge gained relative to the cost.

The Juno Mission completed the Preliminary Design Review (PDR)/Non-Advocate Review (NAR) in FY 2008 and NASA confirmed Juno to proceed to Phase C/D at a 70-percent confidence level. The Juno Mission will start Critical Design Review (CDR) by mid- FY 2009. In FY 2010 the Juno mission will enter into ATLO.

By FY 2010, New Horizons will have long passed the orbit of Saturn on its cruise to Pluto. It is on track for a July 2015 arrival. The cruise period will include periodic spacecraft and instrument checkouts and dress rehearsals for the Pluto fly-by.

The third New Frontiers AO will be released in May 2009. Concept studies selection is expected in 2010.

Project Descriptions and Explanation of Changes

Juno

Juno, now in its development phase, is a mission to Jupiter scheduled to launch in August 2011. The Juno science goals are to: determine the oxygen to hydrogen ratio to determine water abundance and estimate core mass in order to decide among alternative theories of planetary origin; understand Jupiter's interior structure and dynamic properties, including internal convection and the size and mass of its core, through mapping of its gravitational and magnetic fields with unprecedented accuracy; map variations in atmospheric composition, temperature, cloud opacity and dynamics to depths greater than 100 bars at all latitudes; and characterize and explore the three-dimensional structure of Jupiter's polar magnetosphere and auroras. Juno uses a simple, spin-stabilized spacecraft in an elliptical polar orbit that minimizes radiation exposure by flying under Jupiter's radiation belts at perijove and outside them at apojove. Juno's baseline orbit remains continuously in sunlight, resulting in benign and stable thermal conditions. Spin stability eliminates complex, power-hungry attitude control components such as reaction wheels. Additional detail can be found in the Juno Project section of this document and at http://newfrontiers.nasa.gov/missions_juno.html.

Other Missions and Data Analysis

The New Frontiers Future Project provides funds for future New Frontiers space missions to be selected via a competitive Announcement of Opportunity process. The Third Announcement of Opportunity (NF-3) draft was released to the community for comments in late 2008. The AO is expected to be released for competition in May 2009. The science targets for this NF-3 AO include: South Pole Aitken Basin Sample Return, Comet Surface sample return, Venus In-Situ Explorer, Network Mars Science, Trojan/Centaur, Asteroid Sample Return, Io Observer, and Ganymede Observer. Mission selection is expected by late CY 2010 or early 2011.

The New Frontiers Research line provides for the Jupiter Data Analysis Project (JDAP), which broadens the science community participation in the analysis of mission data, and allows scientists outside the selected flight team to look at the data from the mission, do research, and publish their findings. Data access through the New Horizons Research project allows a much broader, and perhaps more objective analysis of data and samples. Without JDAP, the findings and publications would not come out until years after the mission, since the New Horizons mission team members are very busy while the spacecraft is flying. Furthermore, the JDAP project facilitates new ideas and approaches, getting young people started in science, and broadening participation to get a critical mass of scientific talent working on mission data at the critical time. In FY 2010 the JDAP program will move to the Outer Planets Research Program.

On January 19, 2006, the New Horizons mission successfully launched on an Atlas V launch vehicle. New Horizons will reach Pluto and its moon, Charon, in July 2015. New Horizons will conduct a reconnaissance of the Pluto-Charon system, mapping their surface composition and surface temperatures, characterizing their geology, characterizing the atmosphere of Pluto, searching for an atmosphere around Charon, and searching for rings and additional satellites around Pluto.

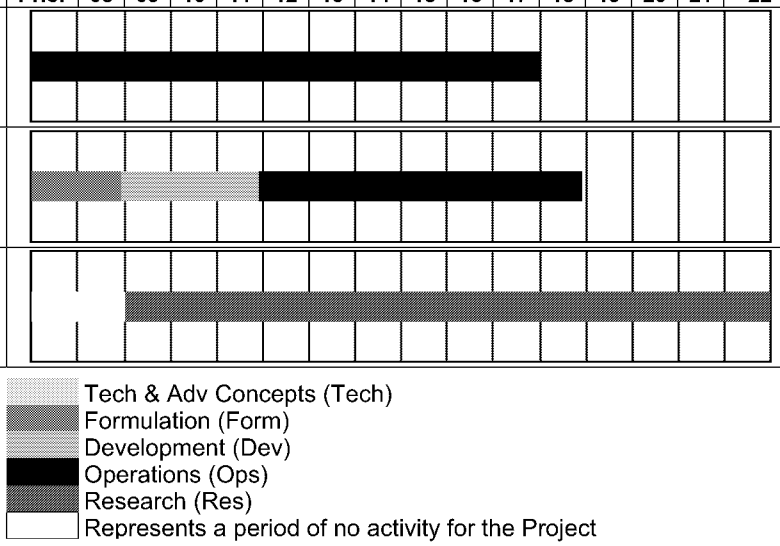
New Frontiers Program Management resides at MSFC and is responsible for selected missions (New Horizons and Juno), and provides for the development of Announcements of Opportunity. The Program Office also supports independent panel review and selection processes.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Launch an average of one mission per 52 months	New Frontiers Program	same

Implementation Schedule



Program Management

The Science Mission Directorate assigns scientific mission priorities and program responsibilities. MSFC has New Frontiers program management responsibility.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
New Horizons	MSFC	GSFC, JPL	None
Juno	MSFC	JPL, KSC, GSFC	Italian Space Agency (ASI)
New Frontiers Research	HQ	Multi-Center	None

Acquisition Strategy

Future acquisitions of New Frontiers missions occur under open Announcement of Opportunity (AO) competitions. The New Frontiers Program solicits proposals for an entire mission (including instruments), put together by teams led by PIs and comprised of people from industry, small businesses, government, and academia.

Major acquisitions for the New Horizons (APL) and Juno (JPL) projects are in place.

The Principal Investigator for New Horizons is at SouthWest Research Institute, Boulder, CO. Johns Hopkins University/Applied Physics Laboratory has project management responsibility.

The Juno Principal Investigator is from the SouthWest Research Institute, San Antonio. Jet Propulsion Laboratory provides mission project management and Lockheed Martin Space Systems will build the spacecraft. The Italian Space Agency, ASI, is contributing the Ka-band and Infrared Spectrometer instrument.

New Frontiers Research will be funded competitively, selected from the ROSES NRA.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2007	Verified compliance with Agency requirements for program implementation and alignment with Agency strategic goals and objectives. The New Frontiers Program provides effective technical and schedule analysis support to the projects and continues to actively use risk-based insight as part of its oversight of the projects. The AO process has proven to be a well-defined, disciplined process that is viewed by the science community as fair and effective.	12/2009

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**130.9**	**95.0**	**245.0**	**237.2**	**174.2**	**71.4**	**17.8**	**18.1**	**102.4**	**1,091.9**
Formulation	130.8	55.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	186.3
Development / Implementation	0.1	39.5	245.0	237.2	158.5	46.9	0.0	0.0	0.0	727.2
Operations / Close-out	0.0	0.0	0.0	0.0	15.7	24.5	17.8	18.1	102.3	178.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	--
FY 2009 President's Budget Request	**130.9**	**108.3**	**245.0**	**225.2**	**168.0**	**14.4**	**17.8**	**--**	**0.0**	**909.5**
Formulation	130.9	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	130.9
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	0.0	108.3	245.0	225.2	168.0	14.4	17.8	--	0.0	778.6
Changes from FY 2009 Request	**0.0**	**-13.3**	**0.0**	**12.0**	**6.2**	**57.0**	**0.0**	**--**	**102.4**	**182.4**
Formulation	-0.1	55.5	0.0	0.0	0.0	0.0	0.0	--	0.0	55.4
Development / Implementation	0.1	39.5	245.0	237.2	158.5	46.9	0.0	--	0.0	727.2
Operations / Close-out	0.0	0.0	0.0	0.0	15.7	24.5	17.8	--	102.3	178.4
Other	0.0	-108.3	-245.0	-225.2	-168.0	-14.4	-17.8	--	0.1	-778.6

Note: The FY 2010 LCC number in the table above is understated by $15.1M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost of Juno will be $1,107.0M, and the estimated development cost will be $742.3M.

Explanation of Project Changes

NASA confirmed Juno to proceed into implementation phase (KDP-C or Phase C/D) on August 05, 2008. The Juno budget is increased to reflect KDP-C decision which established the project's schedule and baseline budget to include a 70% cost confidence level.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Purpose

NASA selected Juno on July 15, 2005, under the New Frontiers Announcement of Opportunity. The overarching scientific goal of the Juno mission is to improve our understanding of the origin and evolution of Jupiter. However, as the archetype of giant planets, Jupiter can also provide knowledge that will improve our understanding of both the origin of our solar system and of planetary systems being discovered around other stars. The investigation focuses on the four science objectives:

Origin: Determine the oxygen-to-hydrogen ratio to determine water abundance and estimate core mass to decide among alternative theories of planetary origin.

Interior: Understand Jupiter's interior structure and dynamic properties through mapping of its gravitational and magnetic fields with unprecedented accuracy, including internal convection and the size and mass of its core.

Atmosphere: Map variations in atmospheric composition, temperature, and cloud opacity and dynamics, to depths greater than 100 bars, at all latitudes.

Magnetosphere: Characterize and explore the three-dimensional structure of Jupiter's polar magnetosphere and auroras.

These objectives have been rated very highly in the National Academy of Sciences' Solar System Exploration Decadal Survey and Sun-Earth Connections Decadal Survey. The Astrophysics Decadal Survey identified the study of star formation, their planetary systems, as well as giant and terrestrial planet birth and evolution as high priority. Juno fulfills key goals outlined in recent NASA and NRC studies and is relevant to NASA's Vision for Space Exploration.

Project Parameters

Juno achieves the science objectives by using a simple spinning, solar-powered spacecraft to make global maps of the gravity, magnetic fields, and atmospheric composition of Jupiter from a unique elliptical polar orbit with a close perijove. The spacecraft carries precise, high-sensitivity radiometers, magnetometers, and gravity science systems. Juno's 32 orbits extensively sample Jupiter's full range of latitudes and longitudes. From its polar perspective Juno combines in-situ and remote sensing observations to explore the polar magnetosphere and determine what drives Jupiter's remarkable auroras.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Commitments

Juno launch date is August 2011, and after a five-year cruise to Jupiter, Jupiter Orbit Insertion (JOI) is scheduled for October 2016. Juno will perform one year of science operations.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Waves	University of Iowa	Measures radio and plasma emissions; 4 m elec. dipole and search coil	Same	Same
Jupiter Energetic particle Detector Instrument (JEDI)	John Hopkins Applied Physics Lab (APL)	Measures auroral distributions of electrons and ions; TOF vs. energy, ion & electron sensors	Same	Same
Gravity Science	Jet Propulsion Lab (JPL)	Maps Jupiter's gravitational field to determine structure of core; X & Ka-band precision Doppler	Same	Same
Flux-Gate Magnetometer (FGM)	GSFC	Maps Jupiter's Magnetic Field (Vector)	Same	Same
Launch Vehicle	KSC	C3 = 32.0 km2/s2, Capability=3545 kg	Same	Same
UV Spectrometer (UVS)	Southwest Research Institute (SwRI)	FUV spectral imager for auroral emissions	Same	Same
Microwave Radiometer (MWR)	Jet Propulsion Lab (JPL)	6 wavelengths (1.3-50 cm); sounds atmosphere to determine water and ammonia abundances	Same	Same
Spacecraft	Lockheed Martin	Solar-powered, spin-stabilized spacecraft in an elliptical polar orbit that minimizes radiation exposure	Same	Same
Jovian Auroral Distributions Experiment (JADE)	Southwest Research Institute (SwRI)	Ion mass spectrometer & electron analyzers; measures auroral distributions of electrons and ions	Same	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Schedule Commitments

Formulation started at project selection in July 2005. Juno proceeded into the implementation phase on August 5, 2008.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Formulation			
PDR	5/2008	same	same
ATLO Readiness	3/2010	same	same
Launch	8/2011	same	same
Development			
CDR	3/2009	same	4/2009

Development Cost and Schedule Summary

Juno was confirmed to proceed into implementation phase (KDP-C or Phase C/D) on August 05, 2008. The budget and schedule reflect the approved Juno Project baseline schedule, development cost, and life-cycle-cost (LCC).

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Juno	2009	742.3	2009	742.3	0	Launch Readiness	8/7/2011	8/7/2011	0

Development Cost Details

Consistent with 1QTR FY2009 MPAR, below is detailed development estimate supporting August 2011 launch readiness date (LRD).

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**742.3**	**742.3**	**0.0**
Spacecraft	236.5	236.5	0.0
Payloads	63.9	63.9	0.0
Launch Vehicle	190.4	190.4	0.0
Ground Systems	8.8	8.8	0.0
Science/Technology	22.1	22.1	0.0
Other Direct Project Costs	220.6	220.6	0.0

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Management

Juno is part of the New Frontiers Program, with program management at Marshall Space Flight Center. The Principal Investigator, from Southwest Research Institute, has delegated day-to-day Juno project management to the Jet Propulsion Laboratory.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Project Management	Project Management & Oversight	JPL	N/A
Jupiter energetic particle instrument (JEDI)	Jet Propulsion Lab (JPL)	None	None
Plasma Waves Experiment (WAVE)	Jet Propulsion Lab (JPL)	None	None
Management; Microwave radiometer, and Gravity Science Experiment	MSFC/New Frontiers Program Office	Jet Propulsion Lab (JPL)	None
Vector Fluxgate Magnetometer (FGM)	Jet Propulsion Lab (JPL)	Goddard Space Flight Center (GSFC)	None
UVS and JADE instruments	MSFC/New Frontiers Program Office	None	None
Flight System, Integration and Test	Jet Propulsion Lab (JPL)	None	None
Overall responsibility for the development, implementation, operation, and success of the mission	MSFC/New Frontiers Program Office	None	None
JunoCam	Jet Propulsion Lab (JPL)	None	None
KaBand and IR science	Jet Propulsion Lab (JPL)	None	Italian Space Agency (ASI)

Acquisition Strategy

All major acquisitions are in place. Juno was selected competitively in July 15, 2005 under a New Frontiers Program Announcement of Opportunity (AO-03-OSS-03).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO /SRB	05/2008	Assess cost, schedule, and risk status of project/Findings for the review showed that cost and schedule for the 2011 launch are consistent with the project's plans.	04/2009

Mission Directorate:	Science
Theme:	Planetary Science
Program:	New Frontiers
Project In Development:	Juno

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Solar Array Performance	Highly possible solar array performance could be less than expected in the low-intensity, low-temperature and high-radiation environment of Jupiter.	Performing early radiation tests on solar cells and conservative estimates of performance. Engaging independent team to assess and validate power generation models and assumptions.
Mass Margin	Highly possible erosion of mass margin as subsystems, such as solar arrays, complete CDR updates.	Scrubbing estimates and contingencies for erosion of mass margin.
Juno-MSL Launch conflict	Possible Juno launch conflict with MSL launch slip to 10/2011 resulting from the required 90-day launch separation window.	Working with MSL and the KSC launch service provider to validate the launch separation requirement and ascertain launch options.
Stellar Reference Unit (SRU) performance	Highly unlikely degraded SRU performance on a spinning spacecraft in a high-radiation environment.	Initiated competitive study contracts and radiation testing to select SRU with best performance to meet project needs.

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Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	709.3	381.6	416.1	494.5	405.5	514.3	536.7
2009 Mars Science Lab	545.0	223.3	204.0	194.6	67.3	65.0	30.0
MAVEN	1.0	6.7	53.4	168.7	182.6	138.4	30.6
Other Missions and Data Analysis	163.3	151.6	158.7	131.2	155.7	310.9	476.1
FY 2009 President's Budget Request	553.5	386.5	299.6	344.5	341.1	413.8	--
2009 Mars Science Lab	305.5	223.3	69.0	54.6	37.6	0.0	--
MAVEN	57.7	6.7	68.5	152.5	170.7	121.8	--
Other Missions and Data Analysis	190.3	156.5	162.1	137.4	132.8	292.0	--
Changes from FY 2009 Request	155.8	-4.9	116.5	150.1	64.4	100.5	--

Program Overview

Mars is the most Earth-like planet in our solar system, with land mass approximately equivalent to the Earth's and what appear to be familiar features such as riverbeds, past river deltas, and volcanoes. Mars has the best planetary record of the first billion years of our solar system and holds scientific clues to the development of the solar system, planets, and maybe life itself. The Mars Program has been developed to conduct a rigorous, incremental, discovery-driven exploration of Mars to determine the planet's physical, dynamic, and geological characteristics.

Phoenix arrived safely on the Martian surface and successfully completed its science objectives, producing stunning science data, the first views of the Martian arctic, discovery of perchlorates in the soil, a much more basic soil than hypothesized, and the first chemical of water (ice) on another planet. Spirit and Opportunity are five years into their surface exploration of Mars, and they continue to return a wealth of new results. Opportunity finished its exploration of Victoria Crater and is now moving south to Endurance Crater, twenty times larger than Victoria. Spirit has survived its third winter and conducted further studies in the area of what remains of an ancient hydrothermal system. The Mars Reconnaissance Orbiter (MRO) has completed its first phase of the science mission and has returned fantastic results highlighting the periodicity in the martian climate and delineating a plethora of minerals that have had interaction with water. Mars Odyssey is still going strong, the gamma-ray spectrometer has leant support to the idea of ancient oceans and the Thermal Emission Imaging System has found new evidence of salt deposits. Meanwhile, MSL delays to the 2011 launch opportunity due to technical/schedule problems and launch window constraint, and the Program has engaged ESA in investigating the options for a joint 2016 mission encompassing their ExoMars rover mission.

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

Plans For FY 2010

Mars Science Laboratory (MSL) will complete remaining hardware builds, conduct Rover System Environmental Test Program, and be at the launch site by the 3rd quarter of FY 2010.

MAVEN will complete Preliminary Design Review (PDR) by 3rd quarter FY 2010.

ExoMars instruments, including potential US collaborations/contributions, will have an extended Phase B in FY 2010.

Odyssey will be in a new orbit with improved sensitivity to detect minerals on the surface.

Project Descriptions and Explanation of Changes

Mars Science Laboratory (MSL)

Currently in its implementation phase, MSL takes a major step forward in Mars exploration, both technically and scientifically, utilizing a new entry, descent, and landing system, a long-duration rover, and ten payload elements for definitive mineralogical and organics measurements. The primary scientific objective is to explore and quantitatively assess a local region on Mars as a potential habitat for past or present life. MSL will lay the ground work for future scientific missions, including Mars Sample Return, and will provide key information for human exploration. Additional detail can be found in the MSL Project section of this document. Due to technical problems and launch window constraints, MSL has been delayed from the 2009 to the 2011 launch opportunity.

Mars Atmosphere and Volatile EvolutioN (MAVEN)

NASA selected the second Mars Scout mission, Mars Atmosphere and Volatile EvolutioN (MAVEN), for formulation phase on September 15, 2008. Currently in it's formulation phase, MAVEN, a robotic orbiter mission, will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses. It will deliver key measurements addressing long-standing questions about the climate history and habitability of Mars. NASA's Goddard Space Flight Center in Greenbelt, MD., will manage the project. Lockheed Martin of Littleton, Colo., will build the spacecraft based on designs from NASA's Mars Reconnaissance Orbiter and 2001 Mars Odyssey missions.

Other Missions & Data Analysis

In its third extended mission operation phase, the primary scientific objectives of Odyssey include more sensitive measurement of the mineralogy of the surface, monitoring of inter -annual variations of Mars climate and surface processes, acquiring future mission landing site data, and continuing as a key telecommunications relay at Mars.

Currently in their sixth extended operation phase, both the Spirit and Opportunity rovers continue to explore geological settings on the surface of Mars using a suite of remote sensing and in-situ instruments. Their objective is to expand our understanding of the history and the geological processes that shaped Mars, particularly those involving water.

Currently in its second extended mission operation phase, the objective of Mars Express, a European Space Agency and Italian Space Agency mission, is to search for sub-surface water from orbit. NASA participates in the scientific analysis of mission data, including the recent investigations into the mysterious deposits of the Medusae Fossae Formation.

Currently in its first extended operation phase, MRO science objectives include: 1)provide high-resolution spectral maps and images for interpretation of the geology of the Martian crust; 2)use ground-penetrating radar to map compositional discontinuation and layering under the surface; and 3)create planetary-scale maps of critical atmospheric properties. MRO is also the key telecommunications relay for the first half of the next decade at Mars.

Mars Mission Operations (MMO) provides management and leadership for the development and execution of Mars multi-mission operations. MMO supports and provides operational capabilities at a lower cost and risk to all current Mars projects.

Once missions have concluded their primary mission phase, further funding for extended operations is allocated based on the findings of a senior review board. Their review of each mission enables them to make recommendations for the allocation of the extended operations budget based on scientific merit.

NASA invests in research and analysis of Mars mission data in order to understand how geologic, climatic, and other processes have worked to shape Mars and its environment over time, as well as how they interact today.

NASA selected Urey and MOMA instrument proposals for technology development studies for potential inclusion in the European ExoMars mission. These instruments, currently in Phase B, would help cement future collaboration with ESA. Due to the ESA schedule, the ExoMars launch has been delayed from 2013 to the 2016 launch opportunity.

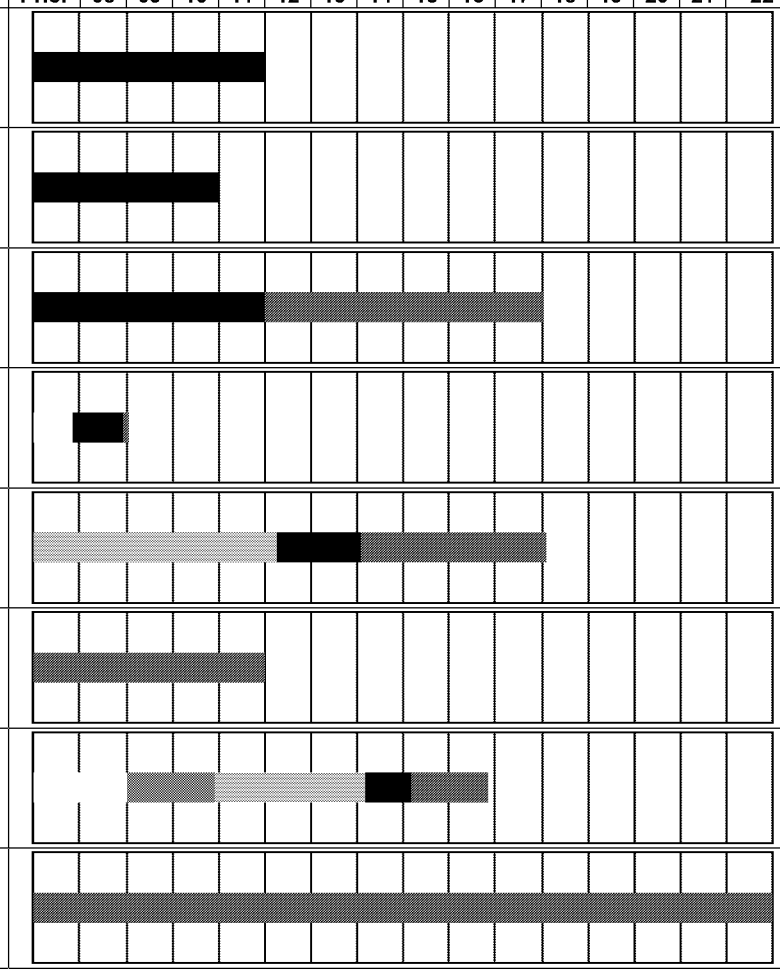
The Mars Exploration Program plans future missions to Mars that build on scientific discoveries from past missions and incorporate the lessons learned from previous mission successes and failures. Missions in planning include a Mars mission in 2016, 2018, and potentially Mars Sample Return (MSR). Due to cost realism, and to better align with international partners' science, technical and schedule requirements, future Mars missions will likely be built on a joint international program and will use envisioned MSR technology to help retire technical risk of the MSR mission as budgets allow. It should be noted that the MSR current costs estimate is mature, but either additional funds or substantial foreign contributions will be required to implement the project in the 2020/2022 timeframe.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
MEP will provide continual operational presence on Mars	Mars Exploration	Same
At least one Mars mission will be launched at every opportunity (every 26 months)	Mars Exploration	Missed the 2009 launch opportunity due to MSL required launch delay

Implementation Schedule



Project	Phase	Beg	End
Mars Odyssey	Tech		
	Form	Apr-97	Apr-99
	Dev	Apr-99	Apr-01
	Ops	Apr-01	Sep-11
	Res		
Mars Exploration Rovers (Spirit & Opportunity)	Tech		
	Form	May-00	Aug-01
	Dev	Aug-01	Jun-03
	Ops	Jun-03	Sep-10
	Res		
Mars Reconnaissance Orbiter (MRO)	Tech		
	Form	Jan-01	Jul-02
	Dev	Jul-02	Aug-05
	Ops	Aug-05	Sep-11
	Res	Oct-11	Sep-17
Mars Scout (Phoenix)	Tech		
	Form	Aug-03	Mar-05
	Dev	Mar-05	Aug-07
	Ops	Aug-07	Aug-08
	Res	Aug-08	Nov-08
Mars Science Laboratory (MSL)	Tech		
	Form	Nov-03	Aug-06
	Dev	Aug-06	Dec-11
	Ops	Dec-11	Oct-13
	Res	Oct-13	Oct-17
Mars Express	Tech		
	Form	Jan-00	Sep-00
	Dev	Sep-00	Jun-03
	Ops	Jun-03	Dec-05
	Res	Dec-05	Sep-11
The Mars Atmosphere and Volatile EvolutioN (MAVEN)	Tech		
	Form	Sep-08	Sep-10
	Dev	Sep-10	Nov-13
	Ops	Nov-13	Dec-14
	Res	Dec-14	Jul-16
Mars R&A	Tech		
	Form		
	Dev		
	Ops		
	Res	Oct-00	Sep-22

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

Program Management

The Jet Propulsion Laboratory has responsibility for implementation of the Mars Exploration Program.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Mars Exploration Rovers (MER)	JPL	JPL, ARC, GRC, JSC, GSFC	None
Mars Reconnaissance Orbiter (MRO)	JPL	JPL, ARC, GSFC, JSC, MSFC	Agenzia Spaziale Italiana (ASI)
Mars Phoenix	JPL	JPL, ARC, JSC	Canadian Space Agency (CSA)
Mars Science Laboratory (MSL)	JPL	JPL , ARC, GSFC, KSC, GRC, LaRC, JSC	Department of Energy; International partners include Canada, Spain, and Russia.
Mars Atmosphere and Volatile EvolutioN (MAVEN)	JPL	GSFC, KSC, JPL	Centre d'Etude Spatiale des Rayonnements (CESR)
Mars Odyssey	JPL	JPL, MSFC	None
Mars Express (MEX)	JPL	JPL, GSFC	European Space Agency (ESA)
ExoMars	JPL	JPL, ARC, LaRC, GSFC	European Space Agency (ESA)

Acquisition Strategy

The Mars Exploration Program (MEP) has set a goal of open competition for all missions. All major acquisitions for MSL, ExoMars instruments, and MAVEN are in place.

Malin Space Systems, Honeybee Robotics, Lockheed Martin, Aeroflex are providing support and hardware for the MSL mission.

The principal investigator for the MAVEN mission is Dr. Bruce Jakosky of the Laboratory for Atmospheric and Space Physics at the University of Colorado at Boulder. NASA's Goddard Space Flight Center in Greenbelt, Md., will manage the project, and Lockheed Martin of Littleton, Colo., will build the spacecraft.

All research and technology is procured through the ROSES announcement and a competitive, peer-review selection process.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	10/2006	A Program Implementation Review was conducted in October 2006. Review determined the Mars program was functioning well and continuing to make important contributions to science and the Vision, but was short on reserve funding. It also found that MSL is critical for future mission science and technology.	12/2009
All	Senior Review Panel	03/2008	Comparative review of Mars operating missions. Missions are ranked in terms of science, engineering capability, and their programmatic roles as they relate to the Mars Exploration program. The findings lead to mission extension for Odyssey, MER, MEX, and MRO, with orbit time change for the Mars Odyssey mission.	03/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**970.1**	**545.0**	**223.3**	**204.0**	**194.6**	**67.3**	**65.0**	**30.0**	**0.0**	**2,299.3**
Formulation	515.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	515.5
Development / Implementation	454.6	545.0	223.3	204.0	194.6	3.5	0.0	0.0	0.0	1,625.0
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	63.8	65.0	30.0	0.0	158.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**969.8**	**305.5**	**223.3**	**69.0**	**54.6**	**37.6**	**0.0**	**--**	**0.0**	**1,659.8**
Formulation	515.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	515.6
Development / Implementation	454.2	305.5	220.0	5.4	0.0	0.0	0.0	--	0.0	985.1
Operations / Close-out	0.0	0.0	3.3	63.6	54.6	37.6	0.0	--	0.0	159.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	**0.3**	**239.4**	**0.0**	**135.0**	**140.0**	**29.7**	**65.0**	**--**	**0.0**	**639.4**
Formulation	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1
Development / Implementation	0.4	239.5	3.3	198.6	194.6	3.5	0.0	--	0.0	639.9
Operations / Close-out	0.0	0.0	-3.3	-63.6	-54.6	26.2	65.0	--	0.0	-0.3
Other	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1

Note: The FY 2010 LCC number in the table above is understated by $6M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of the initial operating plan, the estimated lifecycle cost will be $2,305.3M, and the estimated development cost will be $1,631.0M.

Explanation of Project Changes

A launch date of October 2009 no longer is feasible because of testing and hardware challenges that must be addressed to ensure mission success. The window for a 2009 launch ends in late October. The relative positions of Earth and Mars are favorable for flights to Mars only a few weeks every two years. The next launch opportunity after 2009 is in 2011. NASA announced this delay in December 2008, and estimated the lifecycle cost of the mission to be about $2.3 billion; the FY 2010 Budget request reflects that.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Purpose

The Mars Science Laboratory (MSL) mission is the most technologically challenging interplanetary rover ever designed. It will use new technologies to adjust its flight while descending through the Martian atmosphere, and to set the rover on the surface by lowering it on a tether from a hovering descent stage. Advanced research instruments make up a science payload 10 times the mass of instruments on NASA's Spirit and Opportunity Mars rovers. The Mars Science Laboratory is engineered to drive longer distances over rougher terrain than previous rovers. It will employ a new surface propulsion system.

The MSL Project will make detailed measurements 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 within the regions it will explore.

MSL has four science objectives: assess the biological potential of at least one selected site on Mars; characterize the geology and geochemistry of the landing region at all appropriate spatial scales; identify planetary processes relevant to past habitability; and characterize the broad spectrum of the Martian surface radiation environment.

For more information, see the MSL homepage at http://marsprogram.jpl.nasa.gov/missions/future/msl.html.

Project Parameters

The MSL is a surface rover which will collect Martian soil and rock samples and analyze them for organic compounds and environmental conditions that could have supported microbial life now or in the past. MSL will be a long-duration (two years) roving science laboratory that will be twice as long and three times as heavy (800-850 kilograms) as the Mars Exploration Rovers, Spirit and Opportunity.

Key technologies developed for MSL include: throttle-controlled, high-thrust engines, required during Martian entry, descent, and landing (EDL); sample acquisition and processing equipment used to acquire and distribute samples to the analytic instrument suite; and long-life, high-reliability, thermal-cycle-resistant electronics for use in the rover.

The EDL system will 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.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Commitments

The Mars Science Laboratory (MSL) will be ready to launch in late CY 2011 and will arrive at Mars after approximately 9 months of flight time. MSL will operate for two Earth years on the surface of Mars and will travel approximately 20 kilometers.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Rover	JPL	Travel 20 kilometers over the Martian surface.	Same	Same
Stereoscopic and microscopic cameras	Malin Space Systems	Acquire color, stereo images with resolutions up to 0.2 mm/pixel at 2 m range.	Same	Deleted descent imager and camera zoom
Robotic arm tools	Honeybee Robotics	Acquire, process and deliver 75 rock and soil samples to analytic instruments.	Same	Changed the rock grinder to a brush, sample quantity unchanged
Chemistry camera (ChemCam)	Department of Energy/Los Alamos National Laboratory; France	Remotely measure elemental composition of rocks and soil up to 9m from rover.	Same	Same
Alpha Particle X-ray Spectrometer	Canada (CSA)	Measure with high precision the elemental composition of in situ rocks and soil.	Same	Same
Rover Environmental Monitoring System (REMS)	Spain	Monitor key atmospheric measurements including temperature, pressure, wind speed/direction and humidity.	Same	Same
Dynamic Albedo of Neutrons (DAN)	Russia (IKI)	Measure hydrogen content in subsurface deposits.	Same	Same
Cruise stage and entry system	Lockheed Martin	Transport rover to Martian surface and land with impact speed below 1 m/s	Same	Same
Mission operations and data archive	JPL	Conduct one-year cruise and two-year rover primary mission with remotely located science team.	Same	Same
Sample Analysis at Mars (SAM)	NASA/GSFC	Analysis of elemental and isotopic composition of Mars samples	Same	Same
Chemistry & Mineralogy Instrument (CheMin)	NASA/ARC	Analysis of mineral and chemical content of Mars samples	Same	Same
Sample cache	ARC	Hockey puck-sized container will collect sample of Martian soil for possible later collection by a Mars Sample Return mission	New Commitment	Deleted

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Schedule Commitments

The Mars Science Laboratory Project entered formulation in November 2004, proceeded into the development phase in August 2006, with a launch currently scheduled for late CY 2011.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
Critical Design Review	June 2007	No change	Same
System Integration Review (formerly ATLO)	February 2008	February 2008	Same
Launch Readiness Review	September 2009	September 2009	4QTR CY 2011

Development Cost and Schedule Summary

Project	Base Year	Base Year Develop-ment Cost Estimate ($M)	Current Year	Current Year Develop-ment Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2009 Mars Science Lab	2006	968.6	2009	1,631.0	68	Launch Readiness	9/30/2009	11/7/2011	25

Development Cost Details

Development cost increased due to technical and schedule problems. The current development cost supports the 2011 launch opportunity.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**968.6**	**1,631.0**	**662.4**
Spacecraft	424.8	943.3	518.5
Payloads	64.9	124.3	59.4
Systems I&T	46.5	92.0	45.5
Launch Vehicle/Services	182.6	215.1	32.5
Ground Systems	45.5	77.7	32.2
Science/Technology	11.4	16.9	5.5
Other direct project cost	192.9	161.7	-31.2

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Management

2009 Mars Science Laboratory is a JPL-managed in-house project. Instrument implementation has been assigned to JPL. The responsible NASA official is the Director for the Planetary Science Division.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Rover	JPL	JPL	None
Stereoscopic and microscopic cameras	JPL	None	None
Robotic arm tools	JPL	JPL	None
Chemistry camera (ChemCam)	JPL	None	Department of Energy and France
Alpha Particle X-ray Spectrometer	JPL	None	Canada
Rover Environmental Monitoring System (REMS)	JPL	None	Spain
Dynamic Albedo of Neutrons (DAN)	JPL	None	Russia
Cruise stage and entry system	JPL	JPL, AMES, LaRC	None
Spacecraft	JPL	JPL	None
Sample Analysis at Mars (SAM)	JPL	GSFC	CNES (France)
Chemistry & Mineralogy Instrument (CheMin)	JPL	ARC	None

Acquisition Strategy

All major acquisitions are in place. All major instruments were competitively selected.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ/SRB	11/2008	Assess maturity of MSL design. Design was deemed adequate to achieve mission science goals, but project needs additional time to work the technical problems and perform adequate testing. The finding led to launch delay, from the 2009 to the 2011 launch window opportunity.	03/2009

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Development:	2009 Mars Science Lab

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Actuators and Avionics	Actuator production and assembly delays can possibly threaten overall schedule. Avionics FPGA designs are maturing later than planned due to design complexity and offset between hardware & software development schedules.	Plans are in place to have Actuator Flight Model deliveries completed by June 09, to complete resolution of Avionics design and test issues by September 2009, and to complete Avionics flight deliveries in early 2010.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN (MAVEN)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	1.0	6.7	53.4	168.7	182.6	138.4	30.6
FY 2009 President's Budget Request	57.7	6.7	68.5	152.5	170.7	121.8	--
Total Change from 2009 President's Budget Request	-56.7	0.0	-15.1	16.2	11.8	16.6	--

Project Purpose

MAVEN was selected in September 2008 under the 2006 Mars Scout Announcement of Opportunity. The MAVEN mission will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses. MAVEN will deliver comprehensive answers to long-standing questions regarding the loss of Mars' atmosphere, climate history, liquid water, and habitability. MAVEN will provide the first direct measurements ever taken to address key scientific questions about Mars' evolution. Specific MAVEN science objectives consist of:
- Determine structure and composition of the atmosphere and ionosphere;
- Determine the physical and chemical processes that control loss processes;
- Determine escape rates of neutrals;
- Determine escape rates of ions;
- Determine the external inputs that control upper atmosphere and ionosphere structure and that drive escape; and
- Determine the relative escape rates of the stable isotopes and the resulting isotopic fractionation.

Additional information can be found in http://lasp.colorado.edu/maven/

Project Preliminary Parameters

MAVEN will deliver its science using three instrument packages: a stand-alone neutral gas and ion mass spectrometer (NGIMS), capable of measuring thermal neutrals and ions; a stand-alone imaging ultraviolet spectrometer (IUVS); and the Particles and Fields (P&F) package, consisting of six instruments measuring ionospheric properties, energetic ions, solar wind and solar energetic particles, magnetic fields, and solar extreme ultraviolet irradiance.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN (MAVEN)

Estimated Project Deliverables

The MAVEN measurements will be made from an elliptical orbit with periapsis at 150 km and apoapsis at 6220 km (4.5-hour period). MAVEN will use a sun-pointing, three -axis stabilized spacecraft, with a two-axis gimballed, Mars-pointing platform for the NGIMS, IUVS, and the SupraThermal And Thermal Ion Composition (STATIC) instruments. The spacecraft has a body-mounted high-gain antenna.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Launch Services	United Launch Alliance (ULA)	Intermediate Class launch service		New
Spacecraft	Lockheed Martin	MRO spacecraft bus and avionic suite, with cross strapping and monopropellant propulsion system		New

Estimated Project Schedule

MAVEN will be launched in November 2013, and will arrive at Mars in September 2014.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Formulation			
PDR	3QTR CY2010		New
CDR	3QTR CY 2011		New
ATLO	3QTR CY 2012		New
Launch	4QTR CY 2013		New
Mars Orbit Insertion	September 2014		New

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Mars Exploration
Project In Formulation:	Mars Atmosphere & Volatile EvolutioN (MAVEN)

Project Management

The MAVEN is part of the Mars Program managed by the JPL. The PI from the University of Colorado has delegated the day-to-day management to GSFC.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Program Management	JPL	GSFC	
Project management, msn sys engineering, safety and mission assurance, and project scientist	GSFC	GSFC	
Neutral gas and ion mass spectrometer (NGIMS)	GSFC	GSFC	
Navigation, trajectory, and orbit maintenance analysis	GSFC	JPL	
Magnetometer (MAG) - Measures interplanetary, solar wind, and ionospheric magnetic fields	GSFC	GSFC	

Acquisition Strategy

All major acquisitions are in place. MAVEN was selected competitively on September 15, 2008 under the Mars Scout 2006 Announcement of Opportunity (AO- NNH06ZDA002O).

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
All	Technical Management Cost	08/2008	Reviewed science, technical approach, cost,and schedule. Finding led to selection of the MAVEN mission.	N/A
Performance	IPAO	N/A	Will assess cost, schedule, and risk status of project.	1QFY11

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
N/A	None identified at this time	

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Outer Planets

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	62.2	101.1	98.6	97.1	140.3	117.7	118.5
Outer Planets	62.2	101.1	98.6	97.1	140.3	117.7	118.5
FY 2009 President's Budget Request	81.9	101.1	216.7	279.4	230.6	362.0	--
Outer Planets	81.9	101.1	216.7	279.4	230.6	362.0	--
Changes from FY 2009 Request	-19.8	0.0	-118.1	-182.2	-90.3	-244.2	--

Program Overview

The Outer Planets Program consists of three strategic elements: the ongoing Cassini mission, a new Outer Planets Flagship mission, and the Flagship Data Analysis project. These elements enable science investigations across a broader array of disciplines and in more depth than competed missions. The science discoveries made by these missions are not expected to be easily displaced with time and are expected to overthrow previous paradigms and create new ones in their place.

Plans For FY 2010

Cassini completed its prime mission in July 2008, and started into an extended mission with a new set of science goals. The primary objective of the Cassini extended mission is to continue mission operations at the prime mission level in order to further investigate the discoveries made of Titan and Enceladus during the prime mission. In FY 2010 Cassini will complete its first extended mission at Saturn. This will include performing nine close flybys of Titan, four with Enceladus, and three with other smaller satellites throughout the year. Scientific studies of Saturn, its rings, and magnetosphere will continue. NASA will evaluate a second mission and science extension in late calendar year 2009.

In February 2009 NASA down-selected the Outer Planets Flagship (OPF) from three science targets to focus on the Europa Jupiter System. In addition to further definition study and technology development efforts for the Europa Jupiter System Mission (EJSM) throughout FY 2010, NASA will also continue to negotiate the details of a potential partnership with the European Space Agency (ESA) and other international partners.

Project Descriptions and Explanation of Changes

Outer Planets

NASA plans to fund concept studies and technology development for an Outer Planets Flagship mission. In the 2nd quarter of FY 2009, NASA, working jointly with the European Space Agency, selected a mission to Jupiter and its moon Europa for more detailed concept studies.
Projected mission costs and the resource constraints of our potential international partners preclude a new start during FY 2010.

Cassini-Huygens, in its extended operations phase, is an Outer Planets Flagship mission to Saturn that is profoundly altering our understanding of that planet, its famous rings, magnetosphere, icy satellites, and particularly the moons Titan and Enceladus. Cassini-Huygens is an international collaborative effort with a four year orbiter prime mission. Cassini is the first spacecraft to explore the Saturn system in detail, including its rings and moons. A major focus is Saturn's largest moon, Titan, with its dense atmosphere, methane-based meteorology, and geologically active surface. Launched in October 1997, Cassini arrived at Saturn in July 2004, and will continue with its first extension to investigate Saturn and Titan throughout FY 2010.

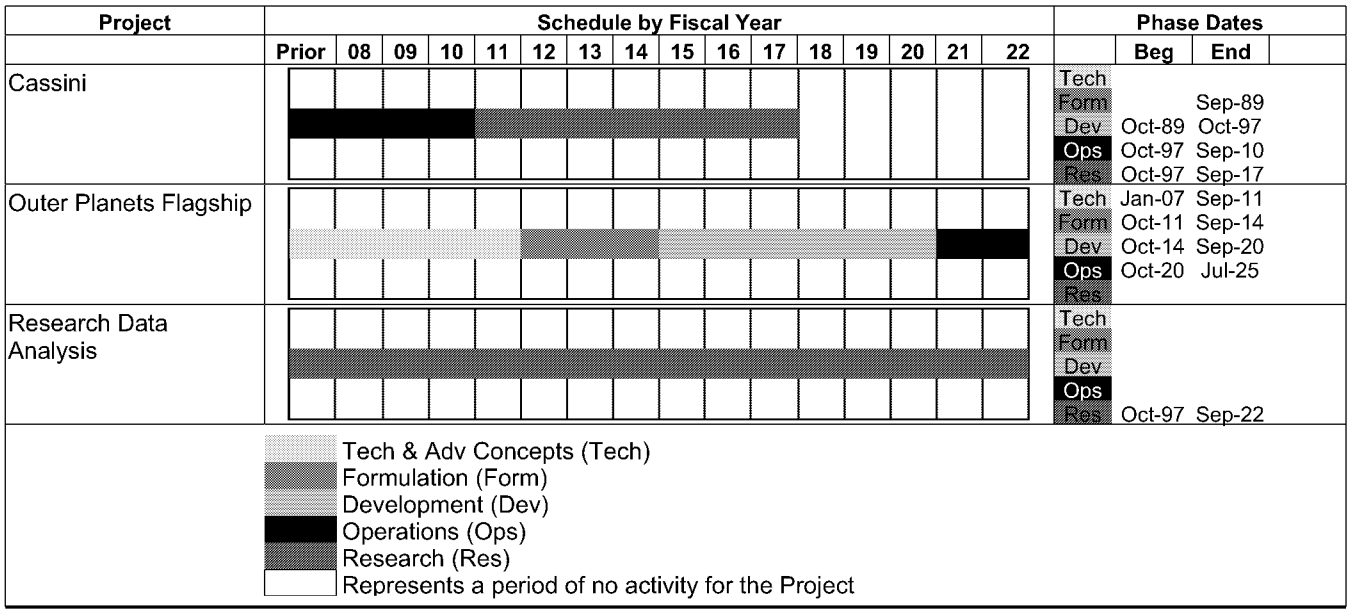
The Cassini Data Analysis Project (CDAP) broadens the science community participation in the analysis of the wealth of new Cassini mission data. The project allows scientists outside the selected flight team to utilize the mission data, conduct research, and publish findings. CDAP dramatically increases the scientific return of the mission and accelerates the rate of that return. Research conducted under CDAP can affect and alter the Cassini imaging targets, such as Titan, and its flybys (e.g., Enceladus plume).

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Deliver science data to Planetary Data Systems (PDS) consistent with science archive plan (in increments within 6 -9 months)	Cassini	Same
Publically release study reports	Outer Planets Flagship	New
Release ROSES and make selections	Research Data Analysis	New

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Outer Planets

Implementation Schedule



Program Management

Program management responsibility for the Outer Planets Flagship Program program resides at JPL. Scientific mission priorities for OPF reside with SMD. The responsible official for this program is the Director of Planetary Science.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Cassini	JPL	JPL	The Italian Space Agency provided Cassini's high-gain communication antenna and the Huygens probe was built by the European Space Agency (ESA).
Outer Planets Flagship	JPL	JPL	ESA
Research Data Analysis	HQ	Multi-Center	None

Acquisition Strategy

All major acquisitions contracts for Cassini are in place. The acquisition strategy for the Outer Planets Flagship (OPF) mission is expected to be similar to Cassini. The OPF science payload will be competitively selected.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Outer Planets

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	02/2007	Cassini senior review for an extended mission recommended approval of the extended mission science. Decision on the Cassini second mission extension is expected in CY 2009.	02/2009
Performance	Independent TMC-Science Panels	12/2009	Independent science, technical, management, and cost review of concept studies. Results pending.	11/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	65.2	64.9	89.0	98.4	102.1	93.5	91.4
Technology	65.2	64.9	89.0	98.4	102.1	93.5	91.4
FY 2009 President's Budget Request	84.8	64.9	69.3	69.6	71.3	73.0	--
Technology	84.8	64.9	69.3	69.6	71.3	73.0	--
Changes from FY 2009 Request	-19.6	0.0	19.7	28.8	30.8	20.6	--

Program Overview

Planetary Science is a challenging endeavor. Future Planetary Science missions will demand advances in both power and propulsion systems to enable successful trips to harsh environments, far from the Sun, with highly challenging trajectories. To meet these needs, the Planetary Science Technology Program includes the In-Space Propulsion (ISP), Radioisotope Power Systems (RPS), and Advanced Multi-Mission Operations System (AMMOS) Projects.

The ISP Project develops in-space propulsion technologies that can enable or benefit near- and mid¬term NASA missions. These technologies will enhance the performance of planetary science missions by allowing increased science payload mass, minimized launch cost and decreased mission trip times. Furthermore, ISP will enable access to more challenging and interesting science destinations. The ISP Project is completing development of several propulsion technologies in support of future Flagship, Discovery, Mars, and New Frontiers missions. The high-temperature chemical thruster development task, high-priority aerocapture ground activities, electric propulsion development efforts for NASA's Evolutionary Xenon Thruster (NEXT) ion system development, and sample return propulsion technology development are the focus core technologies under study and development.

The Radioisotope Power System (RPS) Project advances the capabilities of spacecraft power systems, thereby making it possible for missions to travel to destinations distant from the sun, or where sunlight is obscured or infrequent. RPS is developing a proto-flight Advanced Stirling Radioisotope Generator (ASRG) by the 2013-2014 time frame and is initiating development of a small RPS system for use in distributed network mission environments. RPS continues low-level investments in advanced thermoelectric conversion and thermal photovoltaic technologies as seeds to meet future needs late in the next decades. Consolidation of multi-mission RPS studies and cross-cutting launch approval activities are now included in the RPS project. Funds will be needed to procure nuclear material to support missions in formulation.

The AMMOS Project provides planetary science missions with a set of navigation and design software tools and services for flight mission training, space communications resources allocation, and improved communication and navigation.

Plans For FY 2010

The In-Space Propulsion (ISP) Project will:
- Continue electric propulsion life validation testing and analysis of NASA's Evolutionary Xenon Thruster (NEXT);
- Complete high priority technology development activities (large scale aeroshell manufacturing, Guidance Navigation and Control system testing, and space environmental effects testing) for aerocapture; and
- Continue electric propulsion Hall thruster development task towards Technology Readiness Level 6 (TRL6).

Radioisotope Power Systems (RPS) Project will:
- Continue extended performance testing of the Advanced Stirling Radioisotope Generator (ASRG) engineering unit to provide reliability data;
- Begin development of one Advanced Stirling Radioisotope Generator (ASRG) proto-flight unit for delivery by the 2013-2014 time frame;
- Demonstrate 1500-hour lifetime Radioisotope Thermoelectric Generator couples and validate four-couple module power output; and
- Initiate design of a small Radioisotope Power System (deca-watt class).

Advanced Multi-Mission Operations System (AMMOS) will continue to develop multi-mission software tools for spacecraft navigation and mission planning, efficient spacecraft communication, and data handling.

Project Descriptions and Explanation of Changes

Technology

The In-Space Propulsion (ISP) portfolio invests in high-priority technology areas such as Electric Propulsion (Next-Generation Electric Propulsion), Aerocapture Technology, Advanced Chemical propulsion, and sample return propulsion technology development.

Investments in technology planning allow for strategic studies of focused technology areas that are necessary for the achievement of Planetary Science Theme missions.

The Radioisotope Power Systems (RPS) Project develops and matures component technologies and actively manages the integration of component technologies to flight systems that support multi-mission flight applications. The breadth of the previous project has resulted in the initiation of a project structure to manage this integration. The RPS Project manages both the technology investments and the systems developments and transitions acquisition of flight units to a mission-specific user. The project also assumes responsibility for multi-mission RPS studies and cross-cutting launch approval activities. The project integrates DOE and NASA requirements and assesses long-range planning requirements for nuclear material acquisition.

Returning to Planetary Science in FY 2009 from the Heliophysics Deep Space Mission Systems (DSMS) Program, the AMMOS Project provides multi-mission navigation, design, and training tools to flight missions, and undertakes technology investments for improved communications and navigation technologies.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
NEXT thruster long duration testing achieves grater than 450 kg of Xenon throughput.	ISP	New
2.65m high temp aeroshell with ablative TPS will be fabricated.	ISP	Same
Advanced Stirling Radioisotope Generator engineering model will demonstrate extended operations (7,000 hours).	RPS	Same
Project formulation for a small RPS development will be completed	RPS	New
Provide standard interfaces in order to enable interoperability among missions.	AMMOS	Same

Program Management

SMD provides overall oversight of the technology program. GRC is responsible for the ISP and RPS projects. JPL is responsible for the AMMOS project.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
ISP	GRC	GRC, MSFC, JPL	None
RPS	GRC	JPL, GRC	Department of Energy
AMMOS	JPL	JPL	None

Acquisition Strategy

Technology activities are solicited using the NASA Research Opportunities in Space and Earth Sciences (ROSES) announcement, and selections are made using a competitive, peer-reviewed process. Lockheed Martin and Sunpower are providing support for the RPS Project.