Mission Directorate:	Science
Theme:	Planetary Science

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, satellites, and minor bodies originate and evolve? What are the characteristics of the solar system that lead to habitable environments? How and where could life begin and evolve in the solar system? What are the characteristics of small bodies and planetary environments and what potential hazards or resources do they hold?

To address these science questions, NASA relies on various flight missions, research and analysis (R&A) and technology development. There are seven programs within the Planetary Science Theme: R&A, Lunar Quest, Discovery, New Frontiers, Mars Exploration, Outer Planets, and Technology. R&A supports two operating missions with international partners (Rosetta and Hayabusa), as well as sample curation, data archiving, dissemination and analysis, and Near Earth Object Observations. The Lunar Quest Program consists of small robotic spacecraft missions, Missions of Opportunity, Lunar Science Institute, and R&A. Discovery has two spacecraft in prime mission operations (MESSENGER and Dawn), an instrument operating on an ESA Mars Express mission (ASPERA-3), a mission in its development phase (GRAIL), three Missions of Opportunities (M3, Strofio, and LaRa), and three investigations using re-purposed spacecraft: EPOCh and DIXI hosted on the Deep Impact spacecraft and NExT hosted on the Stardust spacecraft. New Frontiers has one operating spacecraft (New Horizons) and one mission (Juno) currently in its development phase. The Mars Exploration Program has two orbiting spacecraft (Odyssey and MRO) and two rovers (Spirit and Opportunity) in operation, one mission in development (MSL), one scout class mission in formulation (MAVEN) and a science instrument to be included in the ESA ExoMars mission, 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. The Technology Program includes in-space propulsion systems, advanced power generation, and the Advanced Multi-Mission Operations System (AMMOS).

Mission Directorate:	Science
Theme:	Planetary Science

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**1,288.1**	**1,341.3**	**1,485.7**	**1,547.2**	**1,591.2**	**1,630.1**	**1,649.4**
Planetary Science Research	166.2	160.7	180.4	190.8	195.2	214.2	240.9
Lunar Quest Program	69.1	103.6	136.6	136.4	131.7	109.7	110.5
Discovery	234.8	209.2	202.0	216.8	235.9	263.0	312.9
New Frontiers	279.0	264.1	223.8	229.5	237.9	247.7	258.5
Mars Exploration	361.7	416.1	532.8	514.8	549.9	569.6	485.8
Outer Planets	104.8	98.6	103.5	157.9	152.0	144.0	155.8
Technology	72.4	89.0	106.5	101.1	88.7	82.0	85.1
FY 2010 President's Budget Request	**1,325.6**	**1,346.2**	**1,500.6**	**1,577.7**	**1,600.0**	**1,633.2**	**--**
Planetary Science Research	162.1	161.7	193.5	240.2	232.6	254.2	--
Lunar Quest Program	105.0	103.6	142.6	138.6	145.5	118.7	--
Discovery	247.0	213.2	234.6	256.8	256.5	264.3	--
New Frontiers	263.9	264.1	239.9	294.2	239.8	249.6	--
Mars Exploration	381.6	416.1	494.5	405.5	514.3	536.7	--
Outer Planets	101.1	98.6	97.1	140.3	117.7	118.5	--
Technology	64.9	89.0	98.4	102.1	93.5	91.4	--
Total Change from FY 2010 Request	**-37.6**	**-4.9**	**-15.0**	**-30.5**	**-8.7**	**-3.1**	**--**

Note: Zero-sum funds transfer within NASA to consolidate CM&O, institutional facilities, and SBIR. Funds were included for additional NEO activities and carved out within Planetary Science Theme to co-fund Plutonium restart effort with DOE.

Plans for FY 2011

Planetary Science Research

The Research and Analysis (R&A) program will continue to release research announcements and make research project and grant selections. The Planetary Data System (PDS) 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 toward its arrival at comet Churyumov-Gerasimenko (January 2014). Having successfully supported JAXA asteroid mission Earth Return in June 2010, the Hayabusa (MUSES-C) project will start to perform the science and sample analysis phase through September 2011. The expanded NEOO program will improve and increase its efforts to detect Earth approaching asteroids and comets which may provide resources for our exploration of the inner solar system or could become potential impact hazards to the Earth. It will also expand efforts to characterize their nature, both to better understand their composition and provide information for study of potential hazard mitigation techniques.

Lunar Quest Program

Project elements under LQP include the Lunar Atmosphere and Dust Environment Explorer (LADEE), the International Lunar Network (ILN)/ Lunar Surface Science missions, Plutonium, and Lunar Science Research. LADEE completed its preliminary design review in FY 2009 and will enter Implementation Phase (KDP-C) in late FY 2010. The ILN/Lunar Surface Science mission will continue with its the risk reduction efforts during FY 2011. NASA will negotiate and work the Plutonium restart capability with DOE throughout FY 2011. Research Announcement for Lunar Research & Analysis will be released annually, followed by selections and awards.

Discovery

Having completed its third fly-by of Mercury, MESSENGER will prepare for Mercury orbit insertion (planned for March 2011) while it continues its operations and analyses of valuable data from the three flybys. The Dawn spacecraft completed its cruise from a Mars gravity assist in February 2009 to begin its Vesta encounter in May 2011. ASPERA-3 will complete collection of data on its extended mission of Mars Express. Though the M3 instrument will not continue to collect science measurements due to the loss of ISRO's Chandrayaan-1 mission, NASA will continue to perform analysis on the data received. The DIXI mission draws to a close in FY 2011 and NASA will be performing analysis on data collected during its encounter with the comet Hartley 2 in November 2010. Stardust NExT will be the Discovery Program's return to the comet Tempel 1 in February 2011 to see how it has evolved since the Deep Impact encounter in FY 2005. GRAIL will be in Assembly, Test, and Launch Operations (ATLO) by the end of FY 2010 and will prepare for its launch in September 2011. Two new Missions of Opportunity have been selected for the Discovery Program, the Strofio: Exospheric Sample of Mercury's Surface Composition on BepiColombo for a launch in 2014, and LaRa: Lander Radio-science will likely be accommodated as part of joint NASA-ESA Mars program which is currently under negotiation. A new Discovery 12 AO selection will be made by the end of FY 2011 following the AO release in early CY 2010.

New Frontiers

Juno will have successfully completed ATLO during FY 2010, and will deliver all instruments and hardware in preparation for a launch in August 2011. The New Horizons mission will continue on its course toward Pluto and its moons, with periodic spacecraft and instrument checkouts as it cruises. Having recently chosen three concept studies to pursue in 2010, NASA expects to select one New Frontiers 3 mission to proceed into Phase B (or an extended Phase A) by third quarter to late FY 2011.

Plans for FY 2011

Mars Exploration

MSL will complete ATLO and deliver all hardware in preparation for a launch either October or November 2011. The Mars Atmosphere and Volatile EvolutioN (MAVEN), Mars Scout mission, will start implementation phase in the 3rd quarter of FY 2010, leading to a successful completion of PDR and CDR by the end of FY 2011. The U.S. ExoMars instrument will remain in an extended Phase B throughout FY 2011. 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 explore and perform data analysis throughout FY 2011. Concept studies with the ESA-NASA 2016/2018 partnership missions will finalize and the Mars 16 mission will enter into formulation phase by the end of FY 2011.

Outer Planets

NASA Cassini will continue its historic operations and data analysis. In FY 2010 and FY 2011 NASA will continue to provide funding for further definition study and technology development efforts for the Outer Planets Future mission while awaiting the results of the Decadal Survey establishing the science community's highest joint priorities. NASA will also continue to negotiate the details of potential partnerships with the European Space Agency (ESA) and other international partners.

Technology

The In-Space Propulsion Program (ISP) will continue toward a completion of the NASA's Evolutionary Xenon Thruster (NEXT) electric propulsion life validation. The Radioisotope Power Systems (RPS) Program, working with the Department of Energy, will start the flight development of the Advanced Stirling Radioisotope Generator (ARSG) that would support a flight in the 2014-2015 timeframe. Furthermore, the RPS Program continues to develop technologies and processes to support current and future NASA missions. The Advanced Multi-Mission Operation System (AMMOS) project will continue to develop the multi-mission software tools for spacecraft navigation and mission planning throughout FY 2011.

Relevance

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

The Planetary Science Program is guided by the Space Act and subsequent legislation, and by U.S. National Space Policy and related policies, which call on NASA to conduct robotic missions throughout the solar system. The Program follows NASA's tradition of establishing its science priorities through consultation with world-class experts via the National Research Council's decadal survey process. The most recent decadal survey was published in 2002, and the next one is under development for release in 2011. Planetary Science also receives tactical-level advice from the external science community via the Planetary Science Subcommittee of the NASA Advisory Council.

Planetary Science seeks to achieve both near and long-term science goals by studying solar system objects and phenomena primarily in situ, but also by returning samples for study in laboratories on Earth. 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 and may aid in the mitigation of hazards to life here on Earth.

Relevance to education and public benefits:

Planetary Science uses its missions, research programs, and the human resources of the space science community to enhance the quality of American science, technology, engineering and mathematics (STEM) education. The innovative nature of planetary science projects creates an impetus for new techniques and technologies that later benefit the public. Many of our missions are using mission data to create authentic education experiences and engaging students from secondary school through graduate school. The Robotics Alliance Program (RAP) is a concrete example of the Planetary Science program's contribution to education. NASA's Planetary Science 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 STEM employees 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. These missions also enable human space exploration by studying and characterizing alien environments and identifying possible resources that will enable safe and effective human missions to the Moon and beyond.

Mission Directorate:	Science
Theme:	Planetary Science

Performance Achievement Highlights:

NASA scientists discovered the sample from Wild 2 comet (from the Stardust mission) contained crystalline silicates, a rock forming mineral typically found in asteroids. Most asteroids in the solar system are concentrated in a belt between Mars and Jupiter. Wild 2 originated in the Kuiper Belt beyond Neptune, and as a result, the mineral must have been transported from the asteroid belt to the cold, icy reaches of the Solar System to be incorporated into a comet. These findings show that the dust-gas cloud surrounding the primitive Sun before comets, asteroids, and planets began forming was a dynamic system.

A discovery made by the CRISM (Compact Reconnaissance Imaging Spectrometers for Mars) instrument on the MRO offers a better understanding of habitability on Mars. Data from the instrument showed the presence of magnesite, a magnesium-rich carbonate, on the surface of Mars. Scientists had expected to find carbonate on Mars because of its carbon dioxide rich atmosphere and the evidence of water. However, carbonate in bedrock outcrops clearly identifies the geologic environment where it formed and whether the environment could support life. NASA scientists achieved definitive detection of methane and its global variation in the atmosphere of Mars. The discovery indicated the planet is either biologically or geologically active or both. The team found methane in the Martian atmosphere by carefully observing the planet during several Mars years with NASA's Infrared and Keck telescopes. If microscopic Martian life is producing the methane, it likely resides far below the surface where it is warm enough for liquid water to exist. It is possible a geologic process produced the Martian methane, either now or eons ago. On Earth, the conversion of certain iron oxide minerals into a group of more oxidized minerals creates methane. On Mars, this process could occur using water, carbon dioxide and the planet's internal heat.

In FY 2009, asteroid search teams funded by NASA's NEO project found 22 asteroids larger than one kilometer (km) (0.62 miles) in size and two comets with orbits coming within Earth's vicinity. The teams also found 804 smaller asteroids of less than one km in mean diameter, bringing the total number of known near Earth asteroids of all sizes to 6,399. However, 1,066 are in orbits that could become a hazard in the more distant future and warrant monitoring, of which 145 are larger than one kilometer in diameter. Of all these potential hazards, 91 were found this year alone, 4 larger than one km in diameter. A unique event occurred for the first time allowing scientists to collect remnants of a meteorite fall from a parent asteroid whose origin was known. A very small 3 meter sized asteroid on collision course with Earth was spotted before it impacted allowing science teams to collect measurements via remote sensors of the object while it was still in space, and then to search for remnants of the object on the ground. Designated object 2008 TC3, the NEO observer network was quickly alerted and over 570 observations were collected by 27 different observers worldwide, including spectrometric data, within the 19 hours before it impacted the Earth's atmosphere. As a result, fresh and practically uncontaminated fragments have been collected. This is the next best thing to an asteroid sample return mission.

Mission Directorate:	Science
Theme:	Planetary Science

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". Decadal Survey noted that Planetary Science funding reductions overtime have prevent NASA from being able to achieve all of the goals originally envisioned by the Nation's science community in the 2003 Decadal Survey. The next/current Decadal Survey began in 2009.	04/2011

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

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**166.2**	**160.7**	**180.4**	**190.8**	**195.2**	**214.2**	**240.9**
Planetary Science Research and Analysis	**135.6**	**132.1**	**131.0**	**139.0**	**142.4**	**147.4**	**150.4**
Other Missions and Data Analysis	**19.5**	**21.4**	**23.9**	**23.7**	**23.4**	**30.2**	**29.0**
Education and Directorate Management	**7.4**	**1.4**	**5.1**	**7.7**	**8.9**	**16.0**	**40.8**
Near Earth Object Observations	**3.7**	**5.8**	**20.3**	**20.4**	**20.5**	**20.6**	**20.7**
FY 2010 President's Budget Request	**162.1**	**161.7**	**193.5**	**240.2**	**232.6**	**254.2**	**--**
Planetary Science Research and Analysis	**135.0**	**135.1**	**144.4**	**153.2**	**156.9**	**160.7**	**--**
Other Missions and Data Analysis	**19.5**	**21.4**	**22.2**	**22.3**	**22.7**	**29.3**	**--**
Education and Directorate Management	**3.9**	**1.4**	**23.1**	**60.7**	**49.0**	**60.1**	**--**
Near Earth Object Observations	**3.7**	**3.8**	**3.8**	**3.9**	**4.0**	**4.1**	**--**
Changes from FY 2010 Request	**4.0**	**-1.0**	**-13.1**	**-49.3**	**-37.5**	**-40.0**	**--**

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 plan and 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.

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

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

Plans For FY 2011

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

Continue planetary science data archiving and distribution 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 and Genesis.

Support the Rosetta mission toward its arrival at comet Churyumov-Gerasimenko (January 2014),

Complete support to Hayabusa (MUSES-C) for navigation and Deep Space Network Tracking and coordinate Sample Analysis from Earth Return in June 2010 and finish archiving the data in the PDS through 2011.

The budget for Near Earth Objects Observations (NEOO) will significantly expand our efforts to find and characterize asteroids and comets approaching Earth which may be destinations and resources for our exploration of the solar system, or could become potential impact hazards to the Earth.

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

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 of mission concepts and development of instruments for future Discovery, New Frontiers, or Mars missions.

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 FY 2014. The prime scientific objective of the Rosetta mission is to study the nature and 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 its operations phase, is a near-Earth asteroid rendezvous mission that will return samples to Earth. The spacecraft launched in May of 2003 and landed on the Asteroid Itokawa in November 2005. In April 2007, the spacecraft began its return to Earth to bring with it an asteroid sample. Hayabusa will arrive at Earth in June 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 2006.

The Planetary Data Systems (PDS) and Astromaterials Curation Projects provide funds for data archives, sample processing and storage 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.
Robotics Alliance Program (RAP) 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 RAP 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) program 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 to at least 140 meters in size which have any potential to collide with Earth and do significant damage at the surface. In the course of this effort many objects which present viable targets for both robotic and crewed exploration will be found and initially characterized. A significant increase in effort is planned for this program, in accordance with the findings and recommendations of the recent National Research Council study on the NEO hazard, issued January 2010. While it continues to fund the existing network of 1-meter class ground-based telescopes and supporting data processing and analysis infrastructure at the Minor Planet Center and JPL, it will seek to improve the current capability with upgrades and modifications to existing and planned ground and space-based observatory missions. With the additional funding of $16M, it will:
- Extend the collection, archive and analysis of small body data collected by NASA's WISE mission, and support increased follow-up and analysis of this data,
- Enable collection of NEO detection and characterization data by the USAF's Panoramic Survey Telescope and Rapid Reporting System (Pan-STARRS) and investigate the use of other USAF space surveillance assets for this mission,
- Support the continued operation of planetary radar capabilities at the NSF's Arecibo and NASA's Goldstone facilities,
- Begin the investigation of both ground and space-based concepts for increasing capacity to detect, track and characterize Potentially Hazardous Objects (PHOs) down to sizes 140 meters and below, and
- Determine the parameters necessary to understand the characteristics of PHO's important for determination of possible mitigation actions against a detected impact threat.

More information on NASA's NEO program is available at http://neo.jpl.nasa.gov/.

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

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 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
Improve the search for hazardous NEOs, asteroids, and comets down to 140 meters in size that may pose an impact threat.	NEOO	Added elements for upgrading search and characterization of NEOs on NASA, NSF & AF assets.

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End
R&A, PDS, Curation																	Tech Form Dev Ops Res		 Oct-68 Sep-23
Rosetta																	Tech Form Dev Ops Res	 Mar-04 Mar-04 Sep-08	 Sep-17 Sep-17
Hayabusa																	Tech Form Dev Ops Res	 May-03 May-03 Jun-10	 Sep-11 Sep-11
NEOO																	Tech Form Dev Ops Res	 Oct-07	 Sep-23

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

Program Management

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

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	HQs	JSC	NSF and Smithsonian Institution for Antarctic meteorites.
NEOO	HQs	JPL	None

Acquisition Strategy

The R&A FY 2011 budget will fund competitively selected activities from the ROSES-10 (Research Opportunities in Space and Earth Science) Omnibus NRA. All major acquisitions for Rosetta, Hayabusa, Planetary Data System (PDS), and Astromaterials Curation 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. NEOO data processing nodes are located at the Minor Planet Center (Cambridge, MA) and the Sentry high precision orbit determination node at JPL.

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

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Panel of scientists	10/2009	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.	03/2010

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

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**69.1**	**103.6**	**136.6**	**136.4**	**131.7**	**109.7**	**110.5**
Lunar Science	**28.9**	**33.3**	**74.7**	**77.6**	**108.7**	**105.4**	**103.9**
Lunar Atmosphere and Dust Environment Explorer	**30.2**	**55.3**	**57.9**	**54.7**	**18.7**	**0.0**	**0.0**
International Lunar Network	**10.0**	**15.0**	**4.0**	**4.1**	**4.2**	**4.3**	**6.6**
FY 2010 President's Budget Request	**105.0**	**103.6**	**142.6**	**138.6**	**145.5**	**118.7**	**--**
Lunar Science	**64.8**	**33.3**	**52.4**	**58.5**	**64.3**	**39.4**	**--**
Lunar Atmosphere and Dust Environment Explorer	**30.2**	**66.5**	**73.9**	**31.1**	**0.0**	**0.0**	**--**
International Lunar Network	**10.0**	**3.7**	**16.3**	**48.9**	**81.2**	**79.3**	**--**
Changes from FY 2010 Request	**-35.9**	**0.1**	**-6.0**	**-2.1**	**-13.8**	**-8.9**	**--**

Note: Concept studies and independent analysis of the ILN mulit-lander network mission demonstrated that costs greatly exceeded the budget originally envisioned for this effort. NASA will continue to fund concept studies led be the Marshall Space Flight Center to identify and mature technologies associated with small lunar landers. The science priorities specified in the upcoming Planetary Science Decadal Survey will determine whether the Lunar Quest Program should include a lunar lander mission. This will in turn determine whether these technology development efforts should continue.

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

Program Overview

The Lunar Quest Program's (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 possibly 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:

-Provide opportunities to conduct lunar-focused science missions and research;
-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.

LQP is a loosely coupled and a multi-element science program which includes flight missions and research opportunities. Because of identified needs for future missions, it also is a cost-sharing partner with DOE for Plutonium restart infrastructure. Each LQP project will be independent, but they will also have interrelated objectives and a common management and funding structure. The LQP flight opportunities consist of small-medium robotic science spacecraft or landers. The Lunar Atmosphere and Dust Environment Explorer (LADEE), potentially an International Lander Network (ILN), if it is included in the Planetary Decadal Survey, and the Lunar Reconnaissance Orbiter (LRO) science mission are three LQP flight missions. LADEE is currently in formulation phase, with current planned launch date of January 2013. The ILN risk reduction activities are underway, while LRO is in the Exploration Mission operations phase (to be transferred to the LQP in September, 2010). 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, and enticing international collaboration for mutual leverage in accomplishing lunar goals and objectives. Included in the FY 2011 budget request is funding to restart plutonium-238 (Pu-238) production which is an important requirement for future NASA missions.

Plans For FY 2011

Following a LADEE confirmation for Implementation Phase (KDP-C), the project will successfully complete CDR by the end of FY 2011.

Once successfully transferred from ESMD, the LRO Science Mission will operate and perform data analysis throughout FY 2011.

Release Research Announcement soliciting Research & Analysis proposals and make selections.

NASA will work with the Department of Energy (DOE) to define the roles and contributions of major users of Pu-238 in response to Congressional direction.

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

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) and; Lunar Data Competed Studies which analyze new and existing lunar science data procured under other ROSES elements.

In September 2010, ESMD will transfer Lunar Reconnaissance Orbiter (LRO) operational control and funding responsibility to SMD for a two year science mission. The LRO Science Mission will give the scientific community a unique opportunity to concentrate the capabilities of selected LRO instruments on focused lunar science investigations identified from the data obtained during the mapping phase of the mission. The focused investigations will allow us to further improve our understanding of the origin and evolution of the Moon.

The Lunar Science element of the Lunar Quest Program includes funds set aside for future priority decadal mission. These funds could be applied to the International Lunar Network (ILN), pending the recommendations from the Planetary Decadal, the results of which are expected in spring 2011.

Plutonium production is critical to maintaining NASA's ability to explore the solar system, and is an Administration priority. Therefore SMD will begin a jointly funded DOE-NASA effort to restart production capability. NASA will negotiate and work the Plutonium restart capability with DOE starting in FY 2011 until the capability is established.

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

Lunar Atmosphere and Dust Environment Explorer (LADEE)

Currently in Phase B, 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 "The Scientific Context for Exploration of the Moon" (SCEM): to determine the global density, composition, and time variability of the fragile lunar atmosphere. 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. NASA plans to launch LADEE in January 2013. The nominal science mission is 100 days in length. Additional detail can be found in the LADEE project formulation section of this document.

International Lunar Network (ILN)

Concept studies and independent analysis of the ILN mulit-lander network mission demonstrated that costs greatly exceeded the budget originally envisioned for this effort. NASA will continue to fund concept studies led by the Marshall Space Flight Center to identify and mature technologies associated with small lunar landers. The science priorities specified in the upcoming Planetary Science Decadal Survey will determine whether the Lunar Quest Program should include a lunar lander mission. This will in turn determine whether these technology development efforts should continue.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 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	Same

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End
Research																	Tech Form Dev Ops Res	Oct-08	Sep-23
Lunar Reconnaissance Orbiter (LRO) Science Mission																	Tech Form Dev Ops Res	Sep-10 Sep-10	Sep-12 Sep-13
Lunar Atmosphere and Dust Environment Explorer (LADEE)																	Tech Form Dev Ops Res	Mar-08 Sep-10 Feb-13	Sep-10 Jan-13 Sep-13
Plutonium																	Tech Form Dev Ops Res	Oct-10	Sep-23

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

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

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
Research & Analysis	HQ	ARC, GSFC, MSFC, JPL, JSC	N/A
LRO Science Mission	GSFC	GSFC	N/A
LADEE	ARC	ARC, GSFC, HQ/USAF	N/A
Future Decadal Priority	MSFC	TBD	TBD
Plutonium	HQ		DOE

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, the Lunar Surface Science Mission and the LRO science missions are in place. NASA has selected ARC and GSFC to provide the spacecraft for LADEE. Three science instruments have been selected for LADEE: Neutral Mass Spectrometer (NMS), UV Spectrometer (UVS), and Lunar Dust EXperiment (LDEX). The NMS instrument will be provided by GSFC; ARC will provide UVS; and the University of Colorado/LASP will provide LDEX. MIT/LL and GSFC to provide the SOMD LLCD contribution.

GSFC will continue to operate the LRO science mission.

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). Missions 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	12/2009	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.	02/2012

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program
Project In Formulation:	Lunar Atmosphere & Dust Environment Expl

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**30.2**	**55.3**	**57.9**	**54.7**	**18.7**	**0.0**	**0.0**
Total Change from 2010 President's Budget Request	**30.2**	**55.3**	**57.9**	**54.7**	**18.7**	**0.0**	**--**

Note: The cost estimate does not include Lunar Laser Communication Demonstration (LLCD), which is a payload of opportunity funded by the Space Operations Mission Directorate, but not part of the baseline LADEE science mission.

Project Purpose

LADEE, the first mission developed within the Lunar Quest Program, is a cooperative effort between Ames Research Center and Goddard Space Flight Center. The LADEE mission objective is to address high-priority science goals, as identified by the NRC, to determine the global density, composition, and time variability of the fragile lunar atmosphere. LADEE's measurements also will determine the size, charge, and spatial distribution of electrostatically transported dust grains. Additionally, LADEE will carry an optical laser communications demonstrator to be provided by SOMD. The optical laser will technically demonstrate high-bandwidth communication from Lunar orbit.

Project Preliminary Parameters

LADEE spacecraft design is based on a reusable common bus concept, and will be the first space craft based on this bus design. The space craft is a small Class III, Enhanced Class D Orbiter.

Estimated Project Deliverables

The spacecraft is planned for launch in January 2013, into a near circular, lunar equatorial orbit at approximately 50 km. Science operations are planned for 100 days. An extended mission will not be possible under the current plans. In order to maintain orbit, all delta V will be utilized for science data collection, and the mission will be terminated into the lunar surface within three days of completing operations.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	NASA ARC	Small S/C based on reusable design	N/A	New
Integrated Payload	NASA GSFC	3 science Instruments (UVS, NMS, LDEX)	N/A	New
Launch Vehicle	USAF	Medium Class ELV	N/A	New

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program
Project In Formulation:	Lunar Atmosphere & Dust Environment Expl

Estimated Project Schedule

The Science Mission Directorate announced the LADEE project in April 2008 and assigned leadership of the mission to the Ames Research Center (ARC). Project confirmation to proceed into development phase is currently planned for Oct-Nov 2010.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
KDP-C	TBD	n/a	November 2010
LRD	TBD	n/a	January 2013

Project Management

LADEE is part of the Lunar Quest Program (LQP) managed by Marshall Space Flight Center. Space Operations Mission Directorate (SOMD) is providing LLCD, a payload of opportunity, and the funding for this payload.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Project Management	Overall, day-to-day mgt	ARC	N/A
Spacecraft	Design, build and deliver the spacecraft	ARC	N/A
Neutral Mass Spectrometer (NMS) Instrument	Design, build and deliver the NMS instrument. Also responsible for integrating of LDEX and UVS.	GSFC	N/A
UV Spectrometer (UVS) Instrument	Design, build, and deliver	ARC	N/A
Lunar Dust EXperiment (LDEX) Instrument	Design, build, and deliver	University of Colorado, LASP	N/A
Launch Vehicle	Integrate vehicle and provide launch service	TBD	N/A

Acquisition Strategy

Except for launch vehcile, all major acquisitions are in place. The Spacecraft bus was directed to Ames Research Center (ARC) in partnership with Goddard Space Flight Center (GSFC). The Neutral Mass Spectrometer (NMS) was assigned to GSFC and the UV Spectrometer (UVS) was assigned to ARC. The Lunar Dust Experiment (LDEX) was competitively selected through Stand Alone Missions of Opportunity Notice (SALMON) and awarded to the University of Colorado/LASP.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Lunar Quest Program
Project In Formulation:	Lunar Atmosphere & Dust Environment Expl

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	07/2009	Passed Systems Requirements Review, Mission Definition Review, and Preliminary Non-advocate Review.	04/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
S/C design outgrows mass margin allocation	If: additional structural enhancements, power or alternative propulsion options are baselined, Then: the S/C design may outgrow launch vehicle performance.	Mitigate through spacecraft design planning, including management of margins and contingencies per LADEE System Engineering Master Plan, carefully watch launch vehicle performance margins.
Component Vendors Acceptance Testing	If: the as-delivered spacecraft components have gaps in their acceptance level test programs compared to Ames Procedural Requirement 8070.2 requirements, Then: there is a possibility of cost and schedule impacts in order to fully meet components-level acceptance test requirements.	Scope the acceptance test gaps and plan whether to add to existing contracts, test in-house or at a third-party facility. Possibly perform tests at subsystem level. Bring a dedicated procurement officer onto LADEE.
Qualification of Propulsion System	If: the propulsion system for LADEE was qualified for different operating conditions Then: there is the possibility that re-qualification will incur substantial cost and schedule impacts.	Mitigate by early proactive costs control associated with qual testing, facilities, and seeking partners to share the facilities and other cost burden.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**234.8**	**209.2**	**202.0**	**216.8**	**235.9**	**263.0**	**312.9**
Gravity Recovery and Interior Laboratory (GRAIL)	**152.9**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**0.0**
Other Missions and Data Analysis	**81.9**	**85.1**	**97.2**	**175.4**	**231.2**	**263.0**	**312.9**
FY 2010 President's Budget Request	**247.0**	**213.2**	**234.6**	**256.8**	**256.5**	**264.3**	**--**
Gravity Recovery and Interior Laboratory (GRAIL)	**122.4**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**--**
Other Missions and Data Analysis	**124.6**	**89.1**	**129.9**	**215.4**	**251.8**	**264.3**	**--**
Changes from FY 2010 Request	**-12.2**	**-4.0**	**-32.7**	**-40.1**	**-20.6**	**-1.2**	**--**

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 relatively frequent opportunities 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, Genesis, and Moon Mineralogy Mapper) have achieved groundbreaking science, with each taking a unique approach to space exploration. Current Discovery missions include: MESSENGER, Dawn, ASPERA-3, Extrasolar Planet Observations and Characterization (EPOCh), Deep Impact eXtended Investigation (DIXI), StardustNExT, Exospheric Sampling of Mercury's Surface Composition (Strofio), Lander Radio-science on ExoMars (LaRa), 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.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Plans For FY 2011

The MESSENGER spacecraft completed its third flyby of Mercury September 2009 and has made preparations for its Mercury orbit insertion in March 2011.

The Dawn spacecraft will encounter and orbit Vesta for about ten months starting in May 2011.

ASPERA-3 continues to collect data on its extended mission of Mars Express.

The DIXI mission will approach and accomplish the encounter of its target, comet Hartley 2, in November 2010.

The repurposed Stardust NExT mission will approach and accomplish the re-encounter with comet Tempel 1 in February 2011 to detect any changes since the July 2005 Deep Impact mission.

GRAIL has completed its Critical Design Review and begun Assembly, Test, and Launch Operations (ATLO) in preparation for launch scheduled in September 2011.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Project Descriptions and Explanation of Changes

GRAIL

GRAIL continues 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 development section of this document.

Other Missions and Data Analysis

The Dawn mission, now in its cruise operation 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 sequential targets, enabling a detailed and intensive study of both. Dawn launched in September 2007. The Dawn spacecraft will encounter and orbit Vesta for about ten months starting in FY 2011, then travel an additional three years to reach and orbit Ceres.

MESSENGER, a mission to orbit Mercury, launched on August 3, 2004 and is in its cruise operations phase. During the three Mercury flybys that prepare the spacecraft for orbit insertion, it has collected images that provide coverage of all but 2% of the planet and collected detailed information on its geologic history, the nature of its thin atmosphere and very active magnetosphere. MESSENGER carries seven scientific instruments and a radio science experiment to accomplish an ambitious objective: return for the first time comprehensive 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 magnetosphere 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 selected on June 19, 2007, Deep Impact and Stardust spacecraft, both in extended operations phase, have been repurposed for new science missions. The EPOCh mission has used the high-resolution imager 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, Hartley 2, to take pictures of its nucleus and increase understanding of the diversity of comets. These two missions were combined in a joint mission called EPOXI. The Stardust NExT will use the existing Stardust spacecraft for another flyby of comet Tempel 1 to evaluate possible surface erosion since the last flyby in FY 2005.

ASPERA-3, a Mission of Opportunity, is in a second extension of 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 Project was part of the scientific payload for ISRO's Chandrayaan-1 mission which launched October 2008 from India, whose operations were terminated in Aug 2009. 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 science team will be processing the data collected during the shortened mission through CY 2011.

Other Missions & Data Analysis (Continued)

Two new Missions of Opportunity have been selected for the Discovery Program, Strofio: Exospheric Sample of Mercury's Surface Composition, and LaRa: Lander Radio-science on ExoMars. Strofio, in its development phase, will be part of the ESA mission BepiColombo. Strofio will provide valuable information about Mercury's exosphere and its interaction with the magnetosphere and surface. LaRa, currently in a formulation phase, is an instrument that will provide quantitative improvement of several constraints on the structure and state of the interior of Mars. Negotiation is underway where LaRa is to be included as a science instrument in one of the joint NASA/ESA Mars missions.

The Discovery Research line provides funding for: Planetary Mission Data Analysis Program (PMDAP) on archived data collected on Discovery missions; Laboratory Analysis of Returned Samples (LARS) which supports development of new instruments for use in terrestrial laboratories to analyze samples returned from NASA Planetary Science missions; and participating scientists for the MESSENGER and Dawn missions. As stated in the ROSES NRA, the PMDAP 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 PMDAP allows scientists not previously associated with Discovery missions an opportunity to perform data analysis of the data archived in the Planetary Data System. Data access through Discovery Research 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 U.S. 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. The Discovery 2010 AO process will likely result in selection of a new mission by the end of 2011. The Planetary Science Division will continue to work with the Exploration Mission Directorate as their new Exploration Precursor Robotic Program is defined to coordinate and optimize the science return as appropriate.

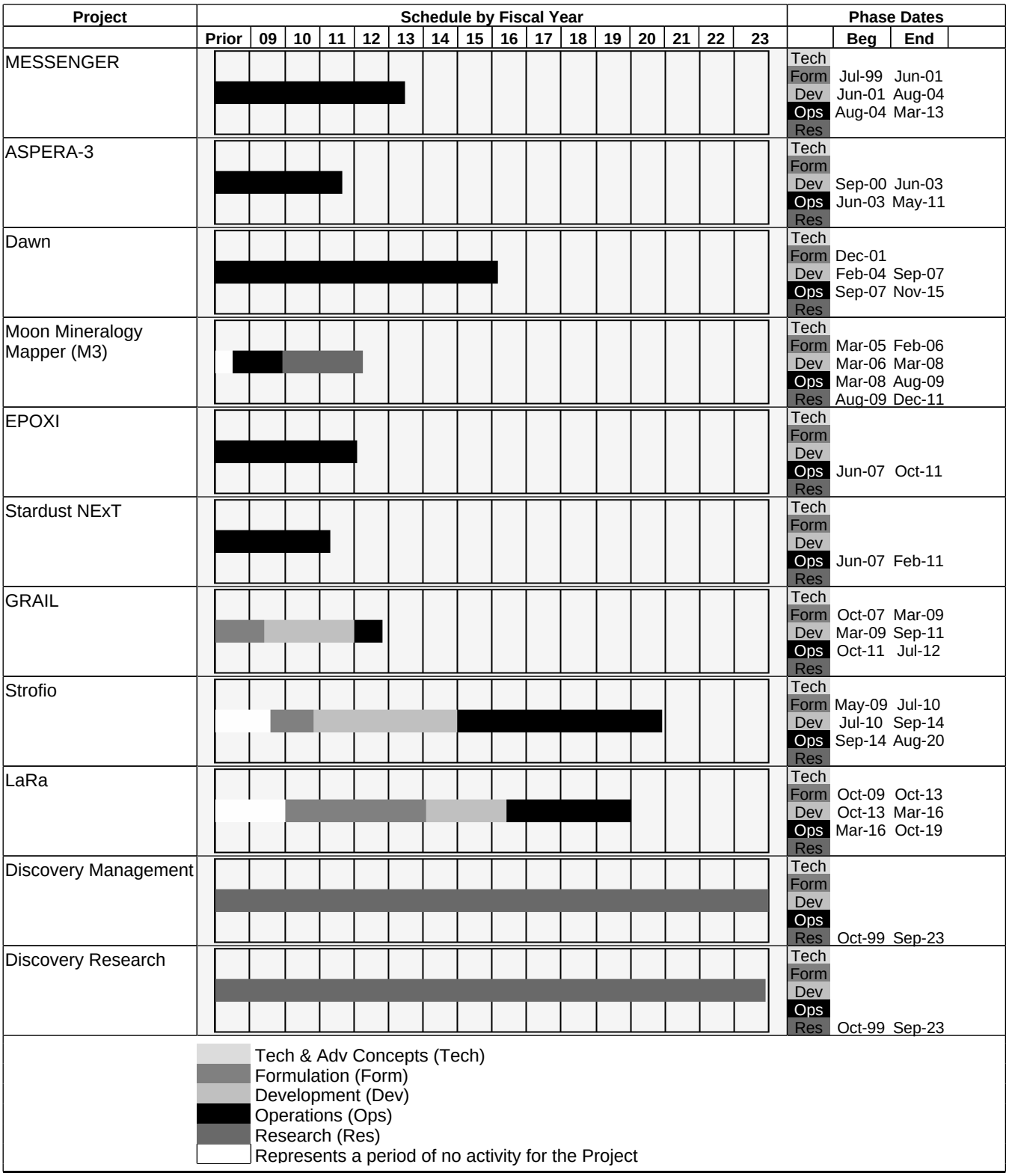
Discovery Program Management provides for the management of the Discovery selected flight missions. This line also provides for the development of Announcements of Opportunity (AOs), supports independent panel reviews, and the mission selection process.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 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, M3, and StardustNExT	Same
Complete design and begin spacecraft or instrument development and assembly	GRAIL, Strofio, LaRA	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Implementation Schedule



Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

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	Applied Physics Laboratory (APL)	GSFC, JPL	None
ASPERA-3	South West Research (SwRI)	MSFC	Sweden; European Space Agency (ESA).
Dawn	JPL	JPL	German Aerospace Center (DLR); Los Alamos National Labs (LANL); Italian Space Agency; and Max-Planck.
M3	JPL	JPL	ISRO Chandrayan spacecraft. USGS.
EPOXI	JPL	JPL	Max-Planck-Institute in Garsching, Germany
Stardust-NExT (Stardust-New Exploration of Tempel)	JPL	JPL	None
GRAIL	JPL	GSFC, JPL, KSC	None
Strofio	SwRI	GSFC	European Space Agency (ESA) BepiColombo Spacecraft.
LaRa	JPL	JPL	European Space Agency (ESA)

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Discovery

Acquisition Strategy

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.

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 and Strofio.

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.

Jet Propulsion Laboratory, California Institute of Technology employs the Principal Investigator for the LaRA Mission of Opportunity.

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 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**68.3**	**152.9**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**0.0**	**0.0**	**496.2**
Formulation	28.2	22.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.5
Development / Implementation	40.1	130.6	124.1	104.5	27.7	0.0	0.0	0.0	0.0	427.0
Operations / Close-out	0.0	0.0	0.0	0.3	13.7	4.7	0.0	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	--
FY 2010 President's Budget Request	**68.3**	**122.4**	**124.1**	**104.8**	**41.4**	**4.7**	**0.0**	**--**	**0.0**	**465.6**
Formulation	28.2	22.3	0.0	0.0	0.0	0.0	0.0	--	0.0	50.5
Development / Implementation	40.1	100.1	124.1	104.5	27.7	0.0	0.0	--	0.0	396.5
Operations / Close-out	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	-0.1
Changes from FY 2010 Request	**0.0**	**30.6**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**--**	**0.0**	**30.6**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	30.5	0.0	0.0	0.0	0.0	0.0	--	0.0	30.5
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	0.0	0.1	0.0	0.0	0.0	0.0	0.0	--	0.0	0.1

Explanation of Project Changes

NASA confirmed GRAIL to proceed into implementation phase (KDP-C or Phase C/D) on January 28, 2009. GRAIL approved baseline development ($427M) and the LCC ($496.2M) numbers remain unchanged since KDP-C.

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 has six lunar science objectives: 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 nearly circular low altitude (50 km) 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 2010 PB Request	FY 2011 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)	Taking 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 2010 PB Request	FY 2011 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	June 2010
Launch Readiness Review	September 2011	Same	Same
End of Prime Mission	June 2012	same	same

Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Gravity Recovery and Interior Laboratory	2009	427.0	2010	427.0	0	Launch Readiness	09/2011	09/2011	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	19.8	1.7
Spacecraft	133.3	141.5	8.2
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	89.8	-9.9

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
Performance	SRB	11/2009	The Critical Design Review was held to assess cost, schedule, and risk status of the project. The findings for the review showed that cost and schedule for the 2011 launch are consistent with the project's plans.	05/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Vehicle	Delta II launch rate is very low in CY 2010 and 2011. The USAF has stopped flying Delta II, and the last launch of the Delta II is currently planned for GRAIL, late in 2011.	ULA is committed to ensuring that the Delta II will be ready and continued insight/oversight with KSC.
Single String Spacecraft	Both GRAIL spacecraft are largely single string.	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.
Reaction Wheel	Light weight Reaction Wheel (RW) is a new development.	If the light weight reaction wheel development falls behind schedule, the project will revert back to an existing RW. The reaction wheel is currently scheduled for a delivery date of June 2010, 2 months before the need date for the start of ATLO.

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

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**279.0**	**264.1**	**223.8**	**229.5**	**237.9**	**247.7**	**258.5**
Juno	**260.1**	**237.2**	**184.2**	**46.4**	**17.8**	**18.1**	**16.8**
Other Missions and Data Analysis	**19.0**	**26.9**	**39.6**	**183.1**	**220.1**	**229.6**	**241.6**
FY 2010 President's Budget Request	**263.9**	**264.1**	**239.9**	**294.2**	**239.8**	**249.6**	**--**
Juno	**245.0**	**237.2**	**174.2**	**71.4**	**17.8**	**18.1**	**--**
Other Missions and Data Analysis	**19.0**	**26.9**	**65.7**	**222.8**	**222.0**	**231.5**	**--**
Changes from FY 2010 Request	**15.1**	**0.0**	**-16.0**	**-64.7**	**-1.8**	**-1.9**	**--**

Program Overview

The New Frontiers Program, comprised of medium to large-sized missions, constitutes a critical element of NASA's solar system exploration capability. NRC-recommended science targets for the New Frontiers Program include Pluto and the Kuiper Belt, Jupiter, Venus, Network Science, Io, Ganymede, Trojan/Centaurs, and sample returns from Earth's Moon, an asteroid, 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.

The New Horizons mission to Pluto is the first peer-review selected mission of the New Frontiers Program. It will conduct reconnaissance of Pluto and its moons Charon, Nixa, and Hydra. New Horizons is currently on its way to its primary target, Pluto. The second New Frontiers mission currently under development is Juno with the overarching scientific goal to understand the origin and evolution of Jupiter and planetary formation. The third New Frontiers AO was released in April 2009. Three mission concept studies were awarded on December 29, 2009. Selection of the final mission is expected by the end of FY 2011, allowing the New Frontiers 3 mission to proceed into Phase B or an extended Phase A.

For more information on the New Frontiers Program, see http://newfrontiers.nasa.gov/index.html.

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

Plans For FY 2011

The Juno Mission continues its development phase. All Juno mission hardware will be fully tested and be delivered to Cape Canaveral in preparation for a launch in August 2011.

The New Horizons spacecraft remains on track for a July 2015 arrival. The project will continue its cruise period throughout FY 2011; work during the cruise period will include annual spacecraft and instrument checkouts and dress rehearsals for the Pluto fly-by.

The third New Frontiers AO was released in April 2009. Selection of New Frontiers 3 proposals for funded mission Phase A concept studies occurred on December 29, 2009. Down-selection of one mission to proceed to the subsequent phases is expected in third quarter to late FY 2011.

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

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 development 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) was released for competition in April 2009. The science targets for this NF-3 AO are those identified in the NRC report Opening New Frontiers in Space: Choices for the Next New Frontiers Announcement of Opportunity (NRC, 2008). Three mission concept studies were awarded on December 29, 2009. These concept missions would probe the atmosphere and crust of Venus; return a piece of a near-Earth asteroid for analysis; or drop a robotic lander into a basin at the moon's south pole to return lunar rocks back to Earth for study. The studies begin during 2010 for 12 months, and the selected mission must be ready for launch no later than Dec. 30, 2018. Mission cost, excluding the launch vehicle, is limited to $650M FY 2009 fixed year dollars. Downselection, to one mission, is currently planned for third quarter to late FY 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 analyze the data from the mission, do research, and publish their findings. Data access through the New Frontiers Research project allows a much broader, and perhaps more objective analysis of data and samples. JDAP also 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.

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 any atmosphere around Charon, and searching for rings and additional satellites around Pluto, including the recently discovered Nixa and Hydra.

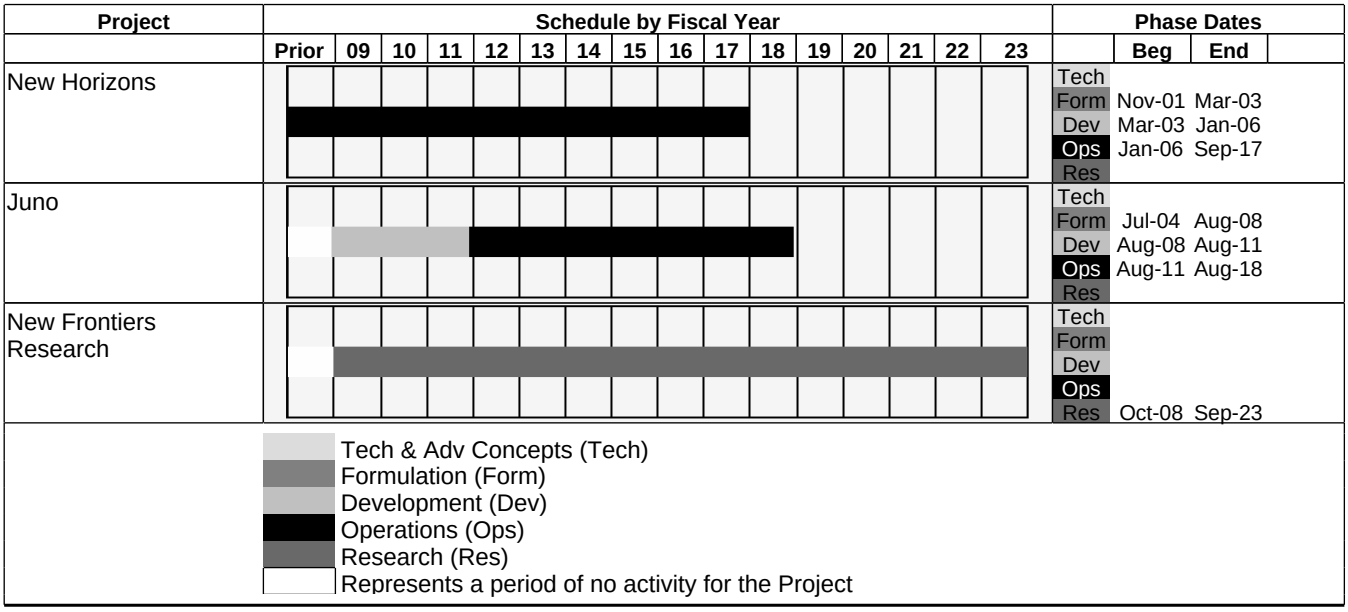
New Frontiers Program Management supports the development of Announcements of Opportunity (AOs), assessments for new missions, and independent management reviews.

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

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 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

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

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 a Principal Investigator 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 is building the spacecraft. The Italian Space Agency, ASI, is contributing the Ka-band Translator and Infrared Spectrometer instrument.

New Frontiers Research will be competitively selected from proposals received in response to 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.	06/2010

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

FY 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**225.9**	**260.1**	**237.2**	**184.2**	**46.4**	**17.8**	**18.1**	**16.8**	**85.6**	**1,092.0**
Formulation	186.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	186.3
Development / Implementation	39.6	260.1	237.2	168.5	22.0	0.0	0.0	0.0	0.0	727.4
Operations / Close-out	0.0	0.0	0.0	15.7	24.4	17.8	18.1	16.8	85.6	178.4
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
FY 2010 President's Budget Request	**225.9**	**245.0**	**237.2**	**174.2**	**71.4**	**17.8**	**18.1**	**--**	**102.4**	**1,091.9**
Formulation	186.3	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	186.3
Development / Implementation	39.6	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	15.7	24.5	17.8	18.1	--	102.4	178.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1
Changes from FY 2010 Request	**0.0**	**15.1**	**0.0**	**10.0**	**-25.0**	**0.0**	**0.0**	**--**	**-16.8**	**0.1**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	15.1	0.0	10.0	-24.9	0.0	0.0	--	0.0	0.2
Operations / Close-out	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	--	-16.8	-0.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--

Note: The FY 2011 LCC number in the table above is understated by $15M due to the difference between the FY 2010 enacted bill and the pending FY 2010 initial operating plan. Assuming approval of the initial operating plan, both the lifecycle and development cost estimates will remain unchanged; the lifecycle cost will remain at $1107M, and the development cost will remain at $742.3M.

Explanation of Project Changes

The funding profile has been modified consistent with NASA risk management plan and strategy. There are no changes to the Juno approved development ($742.3M) nor the LCC ($1107M) baselines since KDP-C.

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, leading to observations of 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.

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

The Juno launch date is August 2011. After a five-year cruise to Jupiter, Juno will enter Jupiter Orbit Insertion (JOI) during October 2016. Juno will perform one year of science operations.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 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 2010 PB Request	FY 2011 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

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Juno	2009	742.3	2010	742.3	0	Launch Readiness	08/2011	08/2011	0

Development Cost Details

Consistent with 1QTR FY 2010 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	282.6	46.1
Payloads	63.9	84.9	21.0
Launch Vehicle	190.4	190.4	0.0
Ground Systems	8.8	11.4	2.6
Science/Technology	22.1	20.8	-1.3
Other Direct Project Costs	220.6	152.2	-68.4

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		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	04/2009	Assess cost, schedule, and risk status of project/Findings for the review showed that cost and schedule for the August 2011 launch are consistent with the project's plans.	03/2010

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

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Flight System Estimate at Complete underestimates Phase C/D cost	The July 2009 Comprehensive Estimate At Complete (CEAC) includes some items and excludes some others that may or may not come to pass. This risk addresses the possibility of large increases in the flight system cost due to the items not included in the July 2009 CEAC	Identify cost savings and Deferral options to reduce the likelihood of large increases in CEAC.
Power Margin at Jupiter	Large variations in solar intensity, solar array temperatures, solar off-point angle, radiation degradation, battery SOC, along with multiple string lengths, larger than normal uncertainties in power supply capabilities make it difficult to assure that all cases are handled with sufficient accuracy	Develop and use integrated system power model; conduct radiation test on larger sample of cells; conduct radiation test on ITO
Completeness of Magnetic Test Approach	If completeness of Juno magnetics verification approach does not adequately verify the effects of Jupiter's magnetic environment on Juno spacecraft (Magnetic susceptibility and residual or induced magnetic dipole effects on MAG measurements) then failure modes may result in loss of mission performance and/or mission success.	Perform material and design susceptibility review to prioritize test items and perform testing on Juno hardware to determine susceptibility
CMIC Design Changes	MRO has experienced 4 in-flight anomalies linked to the CMIC (C&DH Module Interface Card) -- 3 resets and one side-swap. The Juno C&DH also contains a CMIC based on the MRO design. Some design changes have already been made to the Juno CMIC design (re: radiation environment, response to earlier MRO CMIC anomaly) but the root cause of the MRO anomalies is unknown and residual risk exists for Juno.	Add ultimate safe mode within existing architecture; add ability to power off inactive CMIC; evaluate 2 box testing for EMI-EMC and Magnetics

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 Issues	Development issues with the solar arrays, specifically the qualification panel disbonding, moly tab pull test failures, and qualification coupon TVAC test diode failure, may affect readiness of the flight system for environmental testing.	Established Failure Review Board; investigate Moly tab failures; review panel processing and disbanding; inspect Diode tab welds; utilize outside vendor for panel fabrication; investigate ATLO options

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

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	361.7	416.1	532.8	514.8	549.9	569.6	485.8
2009 Mars Science Lab	229.3	204.0	231.6	91.8	42.0	38.5	0.0
MAVEN	6.7	53.4	161.2	210.9	170.5	25.8	18.4
Other Missions and Data Analysis	125.7	158.7	140.0	212.1	337.4	505.3	467.3
FY 2010 President's Budget Request	381.6	416.1	494.5	405.5	514.3	536.7	--
2009 Mars Science Lab	223.3	204.0	194.6	67.3	65.0	30.0	--
MAVEN	6.7	53.4	168.7	182.6	138.4	30.6	--
Other Missions and Data Analysis	151.6	158.7	131.2	155.7	310.9	476.1	--
Changes from FY 2010 Request	-19.9	0.0	38.3	109.3	35.6	32.9	--

Program Overview

Mars is the most Earth-like planet in our solar system, with land mass approximately equivalent to the Earth's, and having 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 Exploration Program has been developed to conduct a rigorous, incremental, discovery-driven exploration of Mars to determine the planet's physical, dynamic, and geological characteristics.

Spirit and Opportunity are six years into their surface exploration of Mars, and they continue to return a wealth of new results. Opportunity has been moving south to Endurance Crater, twenty times larger than Victoria Crater. Spirit has been conducting further studies in the area of what remains of an ancient hydrothermal system. However, Spirit is currently stuck and NASA is assessing the science it can accomplish in situ should extraction prove impossible. The Mars Reconnaissance Orbiter (MRO) is in its extended mission operations phase and is continuing to return results highlighting areas showing morphological, and mineralogical evidence of interaction with liquid water. Mars Odyssey's gamma ray spectrometer has lent support to the idea of ancient oceans, and its Thermal Emission Imaging System (THEMIS) has found new evidence of salt deposits. Meanwhile, the Mars Science Laboratory (MSL) mission continues to achieve technical and schedule progress toward the CY 2011 launch opportunity. MAVEN is the second Mars Scout mission and will study atmospheric processes that will lead to understanding the evolution of the Martian atmosphere. The Program has engaged ESA in investigating the options for a joint 2016 and 2018 mission encompassing their ExoMars rover mission, recently signing an agency to agency agreement for joint missions.

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

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

Plans For FY 2011

Having completed all of its hardware builds and successfully completed the rover environmental test program and ATLO, Mars Science Laboratory (MSL) project will deliver the cruise stage and the rover to the Kennedy Space Center for final assembly in preparation for launch in October-November 2011.

Having successfully completed Preliminary Design Review (PDR) in FY 2010, the MAVEN project plans to successfully complete CDR by the end of FY 2011.

MER, MRO, Odyssey, and ESA's Mars Express will continue to operate, return science data and perform telecom and relay support throughout FY 2011.

NASA and ESA will take their first steps in implementing a joint program of Mars Exploration by soliciting instruments to compete for the opportunity to fly on a Mars 2016 orbiter mission to measure trace gases including methane. Furthermore, collaborative studies will be conducted defining the joint NASA-ESA Mars 2018 mission, which could include rovers from both agencies.

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

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 development section of this document.

Mars Atmosphere and Volatile EvolutioN (MAVEN)

NASA selected the second Mars Scout mission, MAVEN, for formulation phase on September 15, 2008. Currently in its 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 longstanding 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, Colorado, will build the spacecraft based on designs from NASA's Mars Reconnaissance Orbiter and 2001 Mars Odyssey missions. Additional detail can be found in the MAVEN Project section of this document.

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's science objectives include: providing high resolution spectral maps and images for interpretation of the geology of the Martian crust; using ground-penetrating radar to map compositional discontinuities and layering under the surface; and creating 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. Missions under consideration for extension in FY 2011 include MRO, Odyssey, Mars Express, and MER.

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 the Urey and MOMA instrument proposals for technology development studies for potential inclusion in the European ExoMars mission. The ESA ExoMars launch has been delayed from the 2016 to the 2018 joint ESA-NASA launch opportunity, and only MOMA can be accommodated within the ESA mission mass allocation and constraint. MOMA is currently in Phase B and will continue to be in Phase B throughout FY 2011.

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 and 2018, both in collaboration with ESA.

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

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 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	same

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		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 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

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

Program Management

The Jet Propulsion Laboratory has responsibility for implementation of the Mars Exploration Program. Mars Program science resides at Headquarters.

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 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)
Mars 2016 and 2018 Missions	JPL	Multiple Centers	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.

NASA and ESA are planning joint missions in the 2016 (trace gas orbiter) and the 2018 (two rovers) launch opportunity. The intention is to compete science and instruments for these missions, and JPL will implement the ESA/NASA contributions for both missions.

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

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	11/2006	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.	11/2010
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 2011 Budget Request

Budget Authority ($ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	**1,515.1**	**229.3**	**204.0**	**231.6**	**91.8**	**42.0**	**38.5**	**0.0**	**0.0**	**2,352.3**
Formulation	515.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	515.5
Development / Implementation	999.6	229.3	204.0	231.6	13.5	0.0	0.0	0.0	0.0	1,678.0
Operations / Close-out	0.0	0.0	0.0	0.0	78.3	42.0	38.5	0.0	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 2010 President's Budget Request	**1,515.1**	**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	515.5
Development / Implementation	999.6	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	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
Changes from FY 2010 Request	**0.0**	**6.0**	**0.0**	**37.0**	**24.5**	**-23.0**	**8.5**	**--**	**0.0**	**53.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	6.0	0.0	37.0	10.0	0.0	0.0	--	0.0	53.0
Operations / Close-out	0.0	0.0	0.0	0.0	14.5	-23.0	8.5	--	0.0	--
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0

Explanation of Project Changes

While the project continues to make technical, cost and schedule progress, the project still continues to experience technical problems with the actuators, avionics and the titanium. As a result, NASA has adopted a more conservative posture by providing additional funding consistent with NASA risk management plan and strategy. The current LCC is estimated at $2,394.3M, in comparison to the original baseline of $1,642M. SMD anticipates reprogramming additional funds to MSL in the initial FY 2010 operating plan to address the technical problems and related Life Cycle Cost increases.

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 that 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 2010 PB Request	FY 2011 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.	Deleted descent imager and camera zoom	Same
Robotic arm tools	Honeybee Robotics	Acquire, process and deliver 75 rock and soil samples to analytic instruments.	Changed the rock grinder to a brush, sample quantity unchanged	Same
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	Deleted	Same (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 November 2011.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 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	4QTR CY 2011	Same

Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2009 Mars Science Lab	2010	1,719.9	2010	1,719.9	0	Launch Readiness	11/2011	11/2011	0

Development Cost Details

Development cost increased, $95M, to resolve technical problems associated with the actuators, avionics and titanium.

Base or initial estimate was estimate in 2006 at $1642M for LCC and $969M for development. The table below reflects the rebaselined numbers, as established in January 2010.

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**1,719.9**	**1,719.9**	**0.0**
Spacecraft	930.9	975.9	45.0
Payloads	130.3	139.8	9.5
Systems I&T	89.9	96.1	6.2
Launch Vehicle/Services	232.8	232.8	0.0
Ground Systems	74.2	75.4	1.2
Science/Technology	15.9	15.9	0.0
Other direct project cost	245.9	184.0	-61.9

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	05/2009	Assess maturity of MSL design, technical state, and adequacy of resources. Design was deemed adequate to achieve mission science goals, but project needs additional time and resources to work the technical problems and perform adequate testing. The finding resulted in an additional $95M, consistent with NASA risk management plan and strategy, to resolve problems and to ensure mission success.	11/2009

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	Actuator production, life tesing, and assembly delays can possibly threaten overall schedule.	Plans are in place to have Actuator Flight Model complete all of its required life test by March 2010.
Instrument - Sample Analysis at Mars (SAM)	Vacuum pump life could impact SAM science return	Plans are in place to life test a backup pump design by September 2010.

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

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	6.7	53.4	161.2	210.9	170.5	25.8	18.4
FY 2010 President's Budget Request	6.7	53.4	168.7	182.6	138.4	30.6	--
Total Change from 2010 President's Budget Request	0.0	0.0	-7.5	28.3	32.2	-4.8	--

Note: Rephased project reserve profile, and added funds for a higher than anticipated launch vehicle cost.

Project Purpose

Mars Atmosphere and Volatile EvolutioN (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

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 2010 PB Request	FY 2011 PB Request
Launch Services	United Launch Alliance (ULA)	Intermediate Class launch service	New	Same
Spacecraft	Lockheed Martin	MRO spacecraft bus and avionic suite, with cross strapping and monopropellant propulsion system	New	Same

Estimated Project Schedule

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

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
Formulation			
PDR	07/2010	New	Same
CDR	07/2011	New	Same
ATLO	07/2012	New	Same
Launch	11/2013	New	Same
Mars Orbit Insertion	09/2014	New	Same

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

Project Management

The MAVEN is part of the Mars Exploration 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
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
Performance	IPAO & SRB	08/2009	The MAVEN Project passed the System Requirements Assessment conduced by the independent Standing Review Board in August 2009. Will also assess cost, schedule, and risk status of project during PDR.	07/2010

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

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Fault Management Strategy and Science Measurements	If the spacecraft fault-management strategy protecting the spacecraft from the effects of solar-energetic particles is not tailored properly, then solar events and Mars atmospheric measurements key to MAVEN science will be missed.	Tailor inherited spacecraft fault management approach to support MAVEN science. Analysis in Phase B with closure by Fault Protection Peer Review in 2010.
Limited Contact with Spacecraft While Flying Through Atmosphere	If atmospheric density blooming occurs (due to a dust storm, etc) while out of contact and autonomy/safing do not work as expected, then the instruments or spacecraft may be damaged.	Refine Periapsis Timing Estimator algorithm to develop robust safing strategy with closure by Fault Protection Peer Review in 2010.
Aerodynamic Stability During Deep Dips	If the observatory is not aerodynamically stable during deep dips, then the spacecraft may tumble.	Preliminary aerodynamic analysis scheduled as part of Phase B activities. Closure by spacecraft CDR.

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

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**104.8**	**98.6**	**103.5**	**157.9**	**152.0**	**144.0**	**155.8**
Outer Planets	**104.8**	**98.6**	**103.5**	**157.9**	**152.0**	**144.0**	**155.8**
FY 2010 President's Budget Request	**101.1**	**98.6**	**97.1**	**140.3**	**117.7**	**118.5**	**--**
Outer Planets	**101.1**	**98.6**	**97.1**	**140.3**	**117.7**	**118.5**	**--**
Changes from FY 2010 Request	**3.7**	**0.0**	**6.4**	**17.6**	**34.2**	**25.5**	**--**

Note: The current available funds within Planetary Science Theme do not provide for the OPF/EJSM mission beyond its formulation and technology development phases.

Program Overview

The Outer Planets Program consists of three strategic elements: The ongoing Cassini mission to Saturn, a future major outer planets mission, and Supporting Research and Technology (SR&T). These elements enable science investigations across a broader array of disciplines and in more depth than smaller, tightly focused competed missions. The science discoveries made by these strategic 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 2011

The Senior Review Board will determine whether the Cassini project will start its second extended mission to observe seasonal and temporal change in the Saturn system, and will conduct over a dozen flybys of Titan, Enceladus, and other Saturnian moons during FY 2011.

The recommendations of the next planetary science decadal survey, expected in 2011, will play a large role in the selection of the next major outer planets mission.

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

Project Descriptions and Explanation of Changes

Outer Planets

Cassini-Huygens, in its extended operations phase, is an Outer Planets Flagship mission to Saturn that has profoundly altered 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. It was launched in October 1997 and arrived at Saturn in July 2004 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. Cassini completed its prime mission in July 2008 and will complete its first extended mission in FY 2010. The senior review, which was held in February 2009, has recommended that Cassini continue into its second extended science mission. The primary objective of the second extension, the Cassini Solstice mission, is to observe seasonal and temporal change in the Saturn system, especially at Titan, to understand underlying processes, and prepare for future missions. Upon approval, the Cassini Solstice mission will continue to operate through FY 2017.

The Outer Planets program awaits the determination of priorities within the Planetary Science Decadal Survey, currently underway, before proposing a budget and schedule for development of a new major outer planets mission.

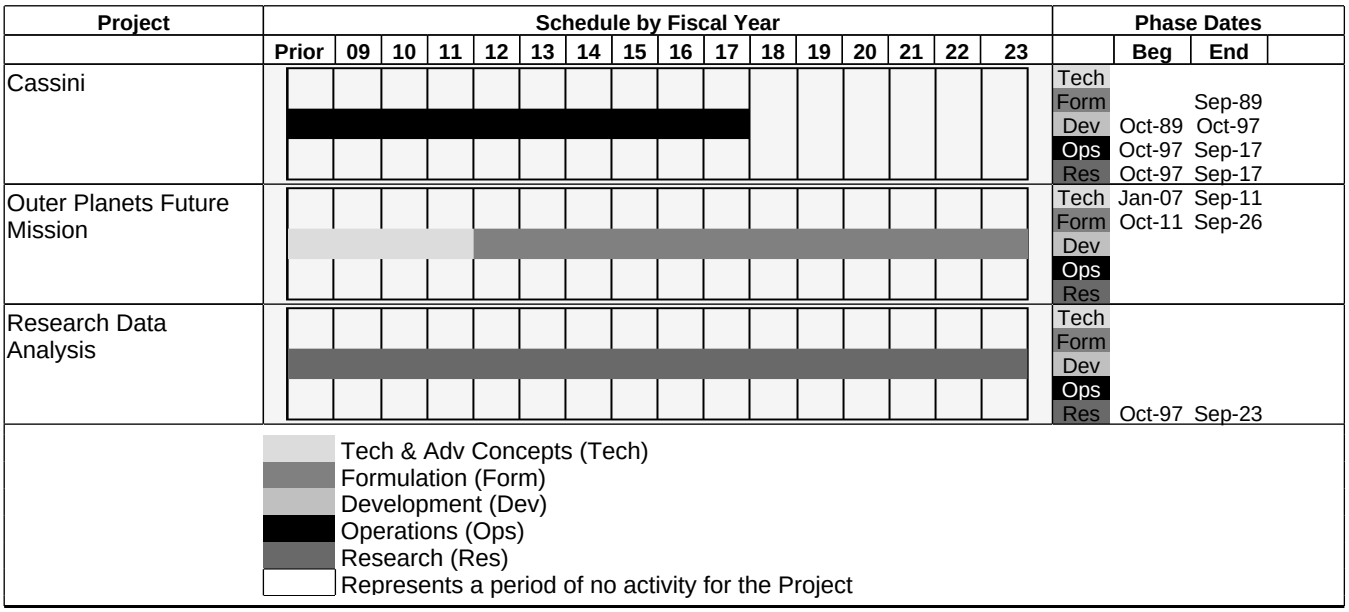
The Supporting Research and Technology (SR&T) effort dramatically increases the scientific return of NASA missions and guides current mission operations (e.g., selecting Cassini imaging targets) as well as future mission planning (e.g., mission concept studies for Titan missions). The competitive programs within the SR&T effort increase our understanding of the outer solar system and broaden the science community participation in the analysis of data returned by Cassini, Galileo, and other missions.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 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	Major Outer Planets Future Mission	Same
Release ROSES and make selections	Research Data Analysis	Same

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

Implementation Schedule



Program Management

Program management responsibility for the Cassini and OPF/Outer Planets Future projects resides at JPL. Scientific mission priorities for the program and the Research efforts reside within SMD/Planetary Science Division.

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 Future Mission	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 future Outer Planets Missions are expected to be similar to Cassini. The science payloads will be competitively selected for the Outer Planets Future Mission.

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

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	02/2009	Cassini senior review for the Solstice extended mission recommended approval of the extended mission science. Decision on the Cassini Solstice mission extension is expected in CY 2010.	02/2011
Performance	Independent Science & Technical Review	12/2008	Independent science, technical, management, and cost review of concept studies.	9/2010

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

FY 2011 Budget Request

Budget Authority ($ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	**72.4**	**89.0**	**106.5**	**101.1**	**88.7**	**82.0**	**85.1**
Technology	**72.4**	**89.0**	**106.5**	**101.1**	**88.7**	**82.0**	**85.1**
FY 2010 President's Budget Request	**64.9**	**89.0**	**98.4**	**102.1**	**93.5**	**91.4**	**--**
Technology	**64.9**	**89.0**	**98.4**	**102.1**	**93.5**	**91.4**	**--**
Changes from FY 2010 Request	**7.5**	**0.0**	**8.2**	**-1.0**	**-4.9**	**-9.4**	**--**

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, reduced launch costs, and decreased mission trip times. 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 flight Advanced Stirling Radioisotope Generators (ASRG) for the 2014 time frame and is conducting a concept study of a small RPS system for use in possible distributed network mission environments. The Advanced Multi-Mission Operations System (AMMOS) Project provides planetary science missions with a set of operations, navigation and design software tools and services for flight mission training, mission operations, space communications resources allocation, and improved space communication.

Mission Directorate:	Science
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Plans For FY 2011

The In-Space Propulsion (ISP) Project will continue electric propulsion life validation testing and analysis of NASA's Evolutionary Xenon Thruster (NEXT) throughout FY 2011 with the goal for completion by FY 2013. The ISP project will also continue electric propulsion Hall thruster development task towards Technology Readiness Level 6 (TRL6) in FY 2010, and initiate Hall system power processing unit (PPU) development in FY 2011.

The Radioisotope Power Systems (RPS) Project will continue an extended performance testing of the Advanced Stirling Radioisotope Generator (ASRG) engineering unit, and continue the development of a qualification unit to enable delivery of one ASRG flight unit for the 2014-2016 Discovery flight opportunity. The RPS will project will demonstrate 1500-hour lifetime Radioisotope Thermoelectric Generator couples and validate four couple module power by the end of FY 2011.

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

In addition, this Technology Program within the Planetary Science theme will pursue complimentary collaborations with the new cross-cutting Space Technology Program within the Office of the Chief Technologist.

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

Project Descriptions and Explanation of Changes

Technology

The In-Space Propulsion (ISP) project will enable access to more challenging and interesting science destinations, including enabling sample return missions. The ISP Project is completing development of several propulsion technologies in support of future Flagship, Discovery, Mars, and New Frontiers missions. ISP portfolio continues to invest in high-priority technology areas such as the Electric Propulsion and Aerocapture technologies identified in the Solar System Exploration (SSE) Roadmap and the 2007 SMD Science Plan. ISP will continue increasing its emphasis on sample return propulsion technology development. The foci will be: completing studies and developing requirements to initiate technology development for Planetary Ascent Vehicles (PAV); completing trade studies and requirements development to kick off technology development for multi-mission Earth Entry Vehicles (MMEEV); continuing advanced chemical propulsion technology development; and initiating other subsystem technology developments for the High Voltage Hall Accelerator (HiVHAC) thruster technology applicable to Earth Return Vehicles (ERV), transfer stages, and low-cost electric propulsion systems for Discovery-class missions.

The Radioisotope Power Systems (RPS) Project continues low-level investments in advanced stirling, thermoelectric conversion and thermal photovoltaic technologies as seeds to meet future needs late in the next decades. The RPS project also funds cross-cutting multi-mission activities to keep them off the critical path, such as NEPA and launch approval engineering. The RPS project is structured to manage both the technology investments and systems development, such as the development and testing of the Advanced Stirling Radioisotope Generator (ASRG). The project transitions acquisition of flight units to a mission-specific user. The project also assumes responsibility for multi-mission RPS studies, sustaining capabilities, and cross-cutting launch approval activities. However, funds are not included within the RPS budget for the procurement of nuclear material required to support missions in formulation.

The Advanced Multi-Mission Operation Support (AMMOS) Project provides multi-mission operations, navigation, design, and training tools for Planetary Science flight missions, and undertakes technology investments for improved communications and navigation technologies.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
HiVHAC Engineering Model (EM) thruster performance acceptance test will be completed	ISP	Same
2.65m high temp aeroshell with ablative TPS will be fabricated to demonstrate manufacturing scale-up.	ISP	Same
Advanced Stirling Radioisotope Generator engineering model will demonstrate extended operations (14,000 hours).	RPS	Same
Provide standard interfaces in order to enable interoperability among missions.	AMMOS	Same

Mission Directorate:	Science
Theme:	Planetary Science
Program:	Technology

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, LARC, ARC	None
RPS	GRC	JPL, GRC, KSC	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. The Department of Energy completed an acquisition for ASRG flight system development (Lockheed Martin) for RPS. JPL provides management and the navigation and space communication software tools.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	National Research Council (NRC)	07/2009	Assessing the restart and sustainment of domestic production of radioisotope heat source material for deep space and other exploration missions. Assessing the development of and standards for flight certification of ASRG for flagship and other missions.	12/2010

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