HELIOPHYSICS

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**639.2**	**620.5**	**647.0**	**643.0**	**636.7**	**638.3**	**661.6**
Heliophysics Research	160.8	175.2	**178.9**	162.6	168.5	170.3	171.6
Living with a Star	218.4	196.3	**232.6**	212.2	286.2	336.6	351.7
Solar Terrestrial Probes	168.3	188.7	**189.4**	179.8	64.5	46.7	53.4
Heliophysics Explorer Program	91.7	60.2	**46.1**	88.4	117.5	84.8	84.8
New Millennium	0.1	0.0	**0.0**	0.0	0.0	0.0	0.0

HELIOPHYSICS RESEARCH

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**160.8**	**175.2**	**178.9**	**162.6**	**168.5**	**170.3**	**171.6**
Heliophysics Research and Analysis	34.0	32.9	**32.7**	31.0	31.5	31.5	31.5
Sounding Rockets	45.9	52.3	**56.1**	51.6	56.3	53.0	53.0
Research Range	19.5	20.1	**20.5**	21.0	21.3	21.6	21.7
Other Missions and Data Analysis	61.4	69.9	**69.6**	58.9	59.5	64.2	65.5
Change From FY 2012 Estimate	--	--	**3.7**				
Percent Change From FY 2012 Estimate	--	--	**2.1%**				

A Virginia Polytechnic Institute and State University experiment was launched February 2011 from the Poker Flat Research Range in Alaska to measure the intensity of nitric oxide in the mesosphere and lower thermosphere in the polar region. Nitric oxide is believed to be a catalyst destroyer of ozone. The data will help scientists understand the abundance of nitric oxide in the lower thermosphere and its relationship to atmospheric processes.

NASA's Heliophysics Research program supports activities that address advancing understanding of the Sun and planetary space environments, including the origin, evolution, and interactions of space plasmas and electromagnetic fields throughout the heliosphere and in connection with the galaxy. The program focuses on understanding the origin and nature of solar activity and its interaction with the space environment of Earth. The program also seeks to characterize these phenomena on a broad range of spatial and temporal scales, understand the fundamental processes that drive them, understand how these processes combine to create space weather events, and enable a capability for predicting future space weather events.

For more information, please see http://science.nasa.gov/about-us/smd-programs/heliophysics-research/.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

No change to program content.

ACHIEVEMENTS IN FY 2011

For Heliophysics Research and Analysis, a number of studies made significant advancement in modeling space weather events based on the latest comparisons to data from our Heliophysics System Observatory. The study of solar wind turbulence research, which is a key aspect of heliospheric science at the root of the solar wind acceleration and particle propagation problems, has taken on a new dimension through

HELIOPHYSICS RESEARCH

creation of a computer code generating model spacecraft data, which now aids in the interpretation of years of spacecraft observations. In October 2011, the Presidential Early Career Award for Scientists and Engineers was awarded to two scientists for their achievements funded by the Solar Heliospheric Supporting Research and Technology program. A final part of the Solar and Heliospheric program is the Low Cost Access to Space. This program supported two extremely successful balloon flights in FY 2011 that provided key measurements of the cosmic ray modulation during this past unusual solar minimum.

In the geospace area, progress during 2011 has focused on inner magnetosphere processes and reconnection processes in anticipation of the upcoming launches of the Radiation Belt Storm Probes (RBSP) and Magnetospheric MultiScale (MMS), respectively. Key progress in research on ultra low frequency and chorus waves in the radiation belts has shown that these are important processes that drive radiation belt acceleration and the precipitation of energetic particles into Earth's atmosphere. The effect of solar storms on Earth's extended atmosphere and its magnetosphere has had increased attention; articles published in *National Geographic* and *New Scientist* in 2011 describing how solar megastorms can cripple satellites have been based on Geospace-funded research. Other ongoing studies have led to an improved understanding of the mesosphere and lower thermosphere. Finally, a major focus of geospace studies in 2011 has been studying the causes and consequences of the minimum of Solar Cycle 24.

The Sounding Rocket project provided support for technology demonstrations, workforce development and educational outreach. The establishment of the Wallops Rocket Academy for Teachers and Students also created new opportunities for K- 12 educators. In science accomplishments, most notable was the Solar Dynamics Observatory/Extreme Ultraviolet Variability Experiment rocket under flight, an essential step in calibrating the EVE dataset.

In FY 2011, SMD launched 12 sounding rockets, supporting five science investigations, one workforce development and training mission, two educational projects, and three technology test and demonstrations. The program also completed a new Flight Termination System design meeting modern flight safety requirements, and worked with the motor vendor on various performance issues, and conducted one deployment campaign to Poker Flat Research Range, AK. In FY 2012, two deployments are planned, to Norway and to Kwajalein Island, in support of Geospace science objectives.

For the operating missions, Interstellar Boundary EXplorer (IBEX) reached its End of Prime Mission in March 2011 and has moved into Extended Phase E. Voyager has had a great deal of press coverage as it is poised to enter the InterStellar Medium within the next few years, and has found that the boundary between the solar system and the InterStellar Medium is not as was previously thought; it is more turbulent and less uniform than suspected. SDO hit the front page of the *Washington Post* newspaper for the coronal mass ejection on June 7, 2011. Moreover, Artemis started science mode in January and February 2011, which marks the first time the solar wind has been measured in the region of space around the moon.

HELIOPHYSICS RESEARCH

KEY ACHIEVEMENTS PLANNED FOR FY 2013

NASA's Heliophysics Research program supports flight programs (sounding rockets, balloons, spacecraft, e.g.) by formulating the theories of the phenomena to be studied; designing the experiments to test these theories; developing the instrument technology needed to execute the experiments; and incorporating results into computational models that can be used to more fully characterize the present state and future evolution of the heliophysics system.

The Supporting Research and Technology program will hold its annual competition for new awards. Participation will be open to all categories of U.S. organizations, from educational institutions to other government agencies. The Geospace Science and Solar and Heliospheric Science sub-elements will hold annual competition for new awards. These sub-elements support detailed research tasks that employ a variety of research techniques, analysis, interpretation of space data, development of new instrument concepts, and laboratory measurements of relevant atomic and plasma parameters. The Theory program supports large principle investigator-proposed team efforts that require a critical mass of expertise to make significant progress in understanding complex physical processes with broad importance. The Low-Cost Access to Space sub-element supports scientific investigation and new instrument concepts to be flown on sounding rockets or balloons, as well as to prepare payloads for future sounding rockets and balloon launches.

Heliophysics data centers will be supported to continue the archival and distribution of collected science data. The Guest Investigator competition will support and extend the scientific impact of the currently operating missions. Science Data and Computing Technology will hold its annual competition for the Applied Information Systems Research program. The Science Data and Computing Technology program will continue to sustain the National Space Science Data Center.

The Sounding Rocket project supports a baseline of 20 to 24 flights per year, including at least one campaign deployment. The 2013 program also includes investment to ensure continued access to motor performance that meets NASA's science requirements. The Research Range project will provide communications, telemetry and tracking instrumentation for NASA suborbital and orbital projects.

BUDGET EXPLANATION

The FY 2013 request is $178.9 million. This represents a $3.7 million increase from the FY 2012 estimate ($175.2 million).

This increase is for a one-time design and development effort for a sustainer motor (a Brant equivalent) for use on future NASA sounding rocket missions. The newly designed motor will provide industry suppliers with a manufacturing design that significantly increases reliability and performance.

The budget for FY 2013 to FY 2016 is slightly more than the notional amounts in the runout of the FY 2012 budget, reflecting the addition of civil service labor.

HELIOPHYSICS RESEARCH

Projects

HELIOPHYSICS RESEARCH AND ANALYSIS

Heliophysics Research and Analysis routinely solicits proposals in several broad areas to advance knowledge in support of NASA strategic goals. In addition, NASA occasionally offers special solicitations to take advantage of research opportunities that arise from the current solar environment. Heliophysics Research and Analysis also funds scientific investigations based on suborbital platforms such as balloons or sounding rockets, and maintains some of the vital communications infrastructure at Wallops Flight Facility. The research and analysis and guest investigator projects fund more in-depth scientific investigations using all of this collected data via a competitive process that is held each year.

U.S. Participating Investigators are complete science investigations that are realized through the participation of U.S. investigators on non-NASA missions and do not involve the development of hardware or software components or complete instruments or subsystems. The science investigations support the scientific goals of the Heliophysics Research and Analysis project.

In FY 2011, NASA funded the Heliophysics Theory, Geospace, and the Solar and Heliophysics programs to better understand complex physical processes with broad importance, such as magnetic reconnection or particle acceleration.

In 2013, NASA will continue to fund in-depth scientific investigations using data collected via a competitive process that is held each year.

SOUNDING ROCKETS

This project funds all suborbital mission activities that support the science investigations using the Sounding Rocket Platform that have been funded in various SMD research and analysis programs, including the Heliophysics Research and Analysis project.

In 2013, NASA will support up to 20 to 24 sounding rocket flights and initiate development of a sustainer motor that will replace the current motor. The current motor is used in more than half of all our science rocket flights, but has caused mission failures due to performance problems for the last five years.

HELIOPHYSICS RESEARCH

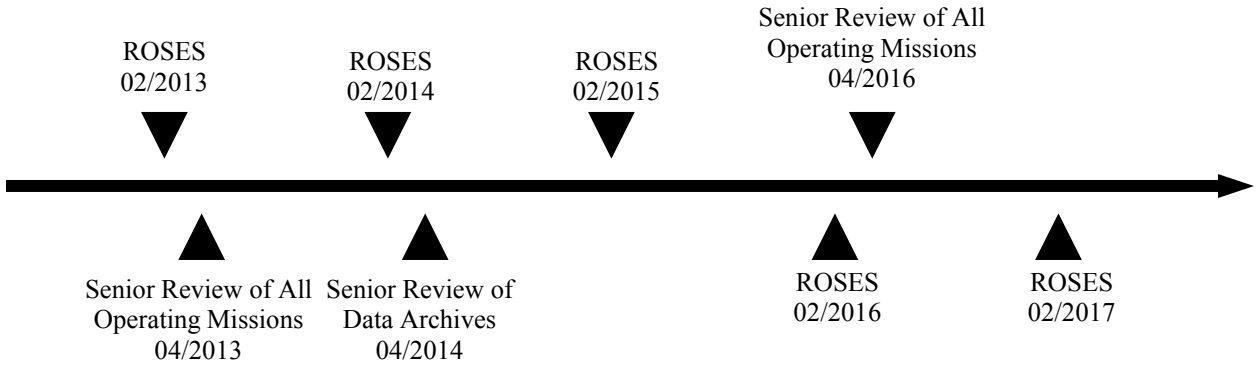
RESEARCH RANGE

The Research Range effort supports NASA's only test range, located at Wallops Flight Facility, for launch of suborbital and orbital vehicles, supporting launch operations, and tracking, telemetry and command capabilities.

In FY 2011, NASA provided the mobile tracking, telemetry and communications support for a sounding rocket deployment to Alaska, and in early FY 2012 to Norway. The Research Range project also provided communications and tracking services to the final Space Shuttle missions, and completed upgrades and maintenance on several tracking radars, range data systems, the mission operations voice enhancement system, wind weighting and impact prediction systems, the lightning detection system, and other range instrumentation.

In 2013, the Research Range program will continue to support sounding rocket campaigns to Alaska and Norway, and provide communications and tracking services for Commercial Resupply Services missions and unmanned aerial systems flights. The Mission Graphics system will be upgraded and certified for use.

Program Schedule



HELIOPHYSICS RESEARCH

Program Management & Commitments

NASA Headquarters has program management responsibility for Heliophysics Research.

Project/Element	Provider
Research and Analysis	Provider: All NASA Centers Project Management: SMD NASA Center: All Cost Share: None
Heliophysics Operating Missions	Provider: GSFC, JPL, and MSFC Project Management: SMD NASA Center: GSFC, JPL, and MSFC Cost Share: None
Sounding Rockets and Research Range	Provider: GSFC Project Management: SMD NASA Center: GSFC Cost Share: None
Science Data and Computing	Provider: GSFC Project Management: SMD NASA Center: GSFC Cost Share: None

Acquisition Strategy

All acquisitions in the NASA's Heliophysics Research programs are based on full and open competition. Proposals are peer reviewed and selected based on NASA Research Opportunities in Space and Earth Sciences (ROSES). Universities, government research laboratories, and industry partners throughout the United States participate in research and analysis projects. The Heliophysics operating missions and instrument teams were previously selected from NASA Announcements of Opportunity. NASA evaluates the allocation of funding among the operating missions bi-annually through the Heliophysics Senior Review. Universities, government research labs, and industry partners throughout the United States participate in science data and computing technology research projects.

HELIOPHYSICS RESEARCH

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
NASA Sounding Rockets Operations Contract	Orbital Science, Corp.	Dulles, VA

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Mission Senior Review Panel	Apr-10	A comparative evaluation of Heliophysics operating missions. A report ranking the operating missions will be released	2013, 2016
Quality	Archives Senior Review Panel	Jun-09	A comparative evaluation of Heliophysics data archives. A report evaluating the value of each archive will be released.	Mar-14

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

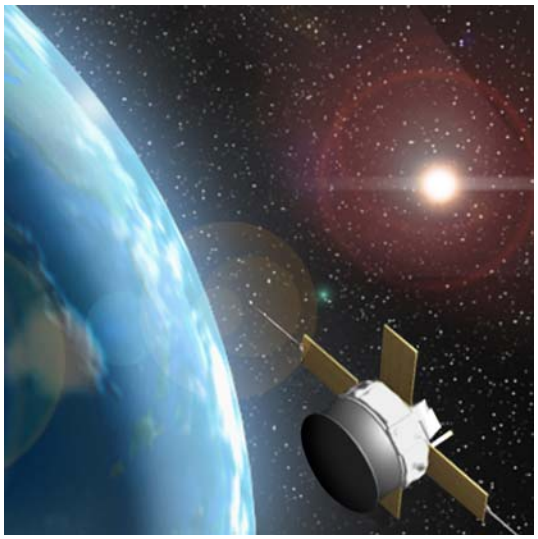
FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**61.4**	**69.9**	**69.6**	**58.9**	**59.5**	**64.2**	**65.5**
Science Planning and Research Support	5.2	5.7	**3.5**	3.6	3.7	3.7	3.8
Directed Research & Technology	0.0	13.5	**11.9**	4.4	6.9	7.4	8.4
SOLAR Data Center	1.0	0.7	**0.8**	0.8	0.8	0.9	0.9
SEC Data & Modeling Services	3.8	3.7	**3.7**	3.7	3.8	3.8	3.9
Space Physics Data Archive	1.4	1.4	**1.3**	1.3	1.3	1.4	1.4
SEC Guest Investigator Program	11.3	10.4	**12.1**	11.9	10.5	13.8	13.8
CCMC	1.8	2.0	**2.0**	1.8	1.8	1.8	1.8
Science Data & Computing	4.8	2.8	**4.2**	4.0	4.2	4.4	4.4
SSC MO Services	9.9	10.1	**10.7**	11.0	11.3	11.6	11.7
GSFC Building Support	3.0	0.0	**0.0**	0.0	0.0	0.0	0.0
Voyager	4.4	5.3	**5.3**	5.4	5.4	5.5	5.5
SOHO	1.9	2.0	**2.1**	2.2	1.9	1.9	1.9
WIND	2.1	2.0	**2.1**	2.2	2.2	2.2	2.2
GEOTAIL	0.3	0.2	**0.2**	0.0	0.0	0.0	0.0
CLUSTER-II	2.1	1.5	**1.2**	0.8	0.0	0.0	0.0
ACE	3.4	3.7	**3.7**	3.7	3.7	3.8	3.8
RHESSI	1.7	1.9	**2.0**	2.1	2.0	2.1	2.1
TIMED	3.0	3.0	**2.8**	0.0	0.0	0.0	0.0
TRACE	0.3	0.0	**0.0**	0.0	0.0	0.0	0.0
Change From FY 2012 Estimate	--	--	**-0.2**				
Percent Change From FY 2012 Estimate	--	--	**-0.4%**				

NASA accumulates, archives, and distributes data collected by operating spacecraft managed by Heliophysics programs. By combining the measurements from all deployed space assets, a Heliophysics System Observatory is created that enables interdisciplinary science across the vast spatial scales of our solar system. Day-to-day operations, a guest investigator program, and space weather "research to operations" are all supported by NASA teams. Heliophysics data centers archive and distribute the collected science data from these missions whose operations are supported by the Living with a Star (LWS), Solar Terrestrial Probes (STP), and Explorers programs. It is this collective asset that enables the data, expertise, and research results that directly contribute to fundamental research on solar and space plasma physics and to the national goal of real-time space weather prediction.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations



The Earth is constantly bombarded with a stream of accelerated particles arriving from the Sun as well as interstellar and galactic sources. Study of these energetic particles by the Advanced Composition Explorer (ACE) spacecraft will contribute to our understanding of the formation and evolution of the solar system as well as the astrophysical processes involved.

In April 2010, the operating missions underwent Senior Review while the data centers were reviewed in July 2010.

Progress in space science is sparked by space observations which also provide the "ground truth" to test simulations, models, and predictions. It is essential the observations be properly recorded, analyzed, released, documented, and rapidly turned into scientific results. The Heliophysics Division has recognized these patterns and funds additional activities to facilitate a smooth data flow: the Solar Data Center, Sun Earth Connection Data and Modeling Services, the Space Physics Data Archive, Science Data and Computing, and Space Science Mission Office Services. These activities undergo a competitive senior review process with the level of support adjusted regularly, according to the anticipated scientific productivity and mission maintenance requirements.

For more information, please see: http://science.nasa.gov/about-us/smd-programs/heliophysics-research/.

Non-Operating Missions

SCIENCE PLANNING AND RESEARCH

This project primarily supports proposal peer review panels, decadal surveys and National Research Council studies, all of which are key to accomplishment of science objectives in the Science Mission Directorate

DIRECTED RESEARCH AND TECHNOLOGY

This project funds the civil service staff that will work on emerging Heliophysics projects, instruments and research. The workforce and funding will transfer to projects by the beginning of FY 2013.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

SOLAR DATA CENTER

The Solar Data Center provides mission and instrument expertise to support the scientifically successful analysis of solar physics mission data. Additionally, it provides leadership for community-based, distributed development efforts to make it easier to identify and access solar physics data, including ground-based coordinated observations residing in the Virtual Solar Observatory. The center also provides a repository for software used to analyze these data.

SEC DATA & MODELING SERVICES

This program provides a mechanism that allows missions which are in long-duration extended Phase E, and those transitioning to Phase F to better prepare their data holdings for long-term archival curation, as typically, missions at the end of their life cycle have insufficient resources to carry out such activities. This program also allows for the creation of higher-level data products, which are of significant use to the science community, and which were not funded in the prime Phase E mission. One-third of the program is competitively competed annually through the ROSES NRA.

SPACE PHYSICS DATA ARCHIVE

The Space Physics Data Facility has a long history of data services from the 1990s. It ensures the long-term preservation and ongoing (online) access (with appropriate services) to non-solar NASA heliophysics science data. It operates key infrastructure components for the Heliophysics Data Environment including inventory and Web service interfaces to systems and data. Additionally, the Space Physics Data Facility provides unique enabling science data services including coordinated data analysis Web, satellite situation center Web/Four-dimensional Orbit Viewer, OMNIweb, and the custom data format standard.

SUN-EARTH CONNECTION GUEST INVESTIGATOR PROGRAM

The Guest Investigator program enables a broad community of researchers in universities and other institutions to use the data from the Heliophysics System Observatory in new, innovative investigations pursuing the scientific goals of the division. The focus of the highly-competitive selected research continuously evolves to ensure that the most important questions are answered.

COMMUNITY COORDINATED MODELING CENTER (CCMC)

CCMC is a multi-agency partnership to enable, support and perform the research and development for next-generation space science and space weather models. The center provides the international research

Formulation	Development	Operations

community with access to modern space science simulations. In addition, it supports the transition to space weather operations of modern space research models.

SCIENCE DATA AND COMPUTING

This program preserves NASA's science data assets for the future generation by working with discipline data systems, their repositories, missions, and investigators. Science Data and Computing provides the space science community with stewardship, guidance, and support so that data made available to the research community by various repositories is well documented in order to provide independent usability. As a repository making unique data and metadata available, Science Data and Computing participates in Virtual Observatory development efforts to assist in the practical evolution of those concepts.

SPACE SCIENCE MISSION OPERATIONS SERVICES

Space Science Mission Operations Services manages on-orbit operations of GSFC Space Science missions. Services include consistent processes for missions operated at GSFC, Johns Hopkins University Applied Physics Laboratory, Orbital Science, Pennsylvania State University, University of California at Berkeley, and Bowie State University. Space Science Mission Operations also sustains an operational infrastructure for current and future missions of Flight Dynamics, the Operational Voice and Data network, GSFC Mission Services Evolution Center, GSFC operational facilities, conjunction assessment, and liaison with the tracking networks such as Ground Network, Space Network, Deep Space Network, and commercial providers.

Operating Missions

VOYAGER

The Voyager spacecraft continue their epic journey of discovery, traveling through a vast unknown region of the heliosphere on their way to the interstellar medium. Voyager 1 and Voyager 2 are both in the heliosheath, making the first in situ observations of the shocked solar wind beyond the termination shock, with the first crossings of the heliopause and the first in situ observations of the local interstellar medium to come. These encounters will address many basic, long-standing questions about the plasma and magnetic properties of the local interstellar medium, the nature of the termination shock and its role in the acceleration of the anomalous cosmic rays, and the role of the heliosheath in the modulation of galactic cosmic rays.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

SOLAR AND HELIOSPHERIC OBSERVATORY (SOHO)

The Large Angle and Spectrometic Coronagraph (LASCO) (a coronagraph is a telescope that uses a disk to occult the sun, allowing us to see the corona, or solar atmosphere) on SOHO is a unique instrument resource at the L1 libration point that is critically important to the Nation's space weather architecture. The extended mission of SOHO, primarily supports the observations of LASCO in the context of the Heliophysics System Observatory, however several of the other instruments can, and do, operate in the extended phase. LASCO is helping scientists understand coronal mass ejections – large bursts of plasma from the sun-and their effect on interplanetary space.

WIND

The Wind spacecraft studies the solar wind and its impact on the near-Earth environment. It addresses wave-particle interaction processes in the space environment, the evolution of solar transients in the heliosphere, and the geomagnetic impact of solar activity. Wind enables in situ studies using unique capabilities, such as three-dimensional particle distributions over a wide range of energies, and delivery at higher time resolution than available from any other mission. Wind is the only near-Earth spacecraft with radio waves instrumentation. The Wind team continues to develop new data products, with analyses of these data products then funded by competitively-selected guest investigator projects. Wind provides important measurements for the understanding of space weather satellite anomalies.

GEOTAIL

The Geotail mission is a collaborative project undertaken by the Japanese Institute of Space and Astronautical Science and NASA. Its primary objective is to study the tail of Earth's magnetosphere. The information gathered is allowing scientists to assess data on the interaction of the solar wind and the magnetosphere.

CLUSTER-II

Cluster is a joint ESA and NASA program, part of ESA's Horizons 2000 program. Cluster uses four spacecraft to make direct measurements of the particles trapped in Earth's magnetic field. By varying spacecraft separations during repeated visits to regions, Cluster can measure the small scale fluctuations in interplanetary space.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

ADVANCED COMPOSITION EXPLORER (ACE)

ACE measures the composition of the solar-wind, solar energetic particles, anomalous cosmic rays , and galactic cosmic rays with sensitivity, precision, and energy ranges that are not found on any other Heliophysics System Observatory mission. ACE addresses heliophysics science goals such as understanding solar particle acceleration and transport, establishing the structure and evolution of the solar wind, probing the global heliosphere and interstellar medium; and characterizing the space environment. ACE also functions as a real-time upstream solar-wind monitor for NASA, NOAA, and other users. Because ACE is well past its predicted mission lifetime, the agencies responsible for space weather prediction are studying options for an ACE replacement mission.

REUVEN RAMATY HIGH ENERGY SOLAR SPECTROSCOPE IMAGER (RHESSI)

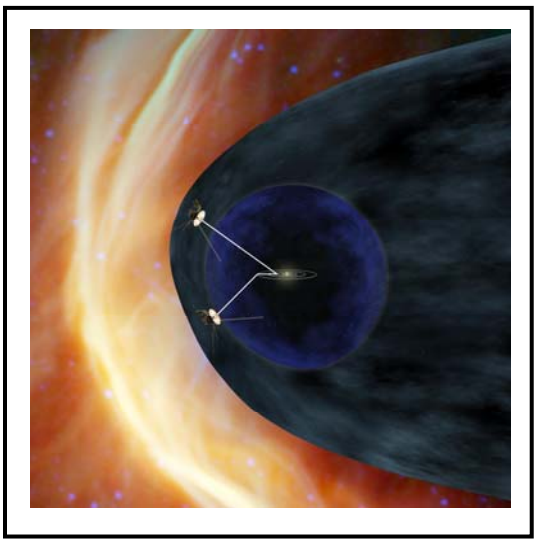
RHESSI studies solar flares in X-rays and gamma-rays. It explores the basic physics of particle acceleration and explosive energy release in these energetic events in the Sun's atmosphere. Throughout its eight year duration, the RHESSI mission primarily has addressed one fundamental unsolved question in heliophysics: How are particles accelerated in solar eruptions? Observations will span nearly a full solar cycle by the end of the extended mission, allowing detection of any connections between flare particle characteristics and the phase of the cycle.

THERMOSPHERE, ION, MESOSPHERE, ENERGETICS AND DYNAMICS (TIMED)

The TIMED mission characterizes and studies the physics, dynamics, energetics, thermal structure, and composition of the least well-understood region of the Earth's atmosphere, the mesosphere-lower thermosphere-ionosphere system. This region of interest, located between altitudes of approximately 60 to180 kilometers above the surface of Earth, is the interface between the Earth's lower atmosphere below and the magnetosphere above, and can be influenced by forcing from either of these regions. The mesosphere-lower thermosphere-ionosphere system can undergo rapid changes in character due to both natural and human-induced (anthropogenic) effects.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations



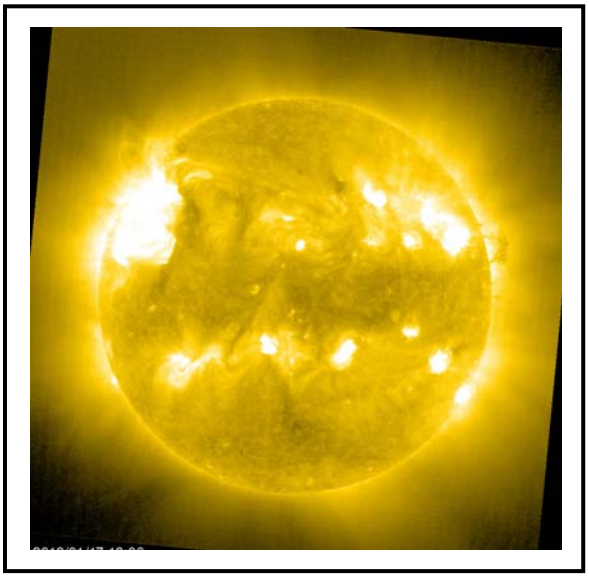
Recent Achievements

VOYAGER

Observations from NASA's Voyager spacecraft suggest the edge of our solar system may not be smooth, but filled with a turbulent sea of magnetic bubbles. While using a new computer model to analyze Voyager data, scientists found the Sun's distant magnetic field is made up of bubbles approximately 100 million miles (160 million kilometers) wide. The bubbles are created when magnetic field lines reorganize. The new model suggests the field lines are broken up into self-contained structures disconnected from the solar magnetic field. The findings are described in the June 9, 2011 edition of the *Astrophysical Journal*.

SOHO

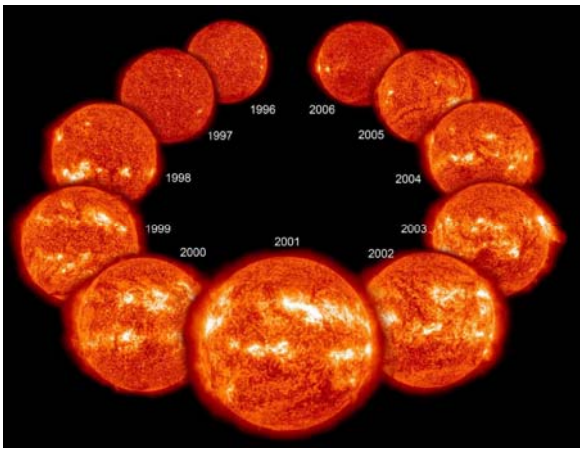
After detailed analysis of data from the SOHO and Geodetic Earth Orbiting Satellite spacecraft, a team of European scientists has been able to shed new light on the role of solar flares in the total output of radiation from the nearest star. Their surprising conclusion is that x-rays account for only about one percent of the total energy emitted by these explosive events.



LIVING WITH A STAR (LWS)

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**218.4**	**196.3**	**232.6**	**212.2**	**286.2**	**336.6**	**351.7**
Radiation Belt Storm Probes	146.1	86.1	**37.7**	14.5	9.1	0.0	0.0
Solar Probe Plus	13.9	49.5	**112.1**	103.2	137.1	229.3	215.2
Solar Orbiter Collaboration	8.3	21.3	**21.3**	58.2	102.1	75.6	100.0
Other Missions and Data Analysis	50.2	39.3	**61.5**	36.3	37.8	31.8	36.5
Change From FY 2012 Estimate	--	--	**36.3**				
Percent Change From FY 2012 Estimate	--	--	**18.5%**				



Solar cycle 23 was the 23rd solar cycle since 1755, when recording solar sunspot activity began. It lasted 12.6 years, beginning in May 1996 and ending in December 2008. During solar maximum, huge sunspots and intense solar flares are more frequent. Auroras can appear in Florida, radiation storms saturate satellite components, and radio blackouts impede emergency responders. The last solar maximum took pace in the years around 2000-2001. During solar minimum, the opposite occurs, and solar flares and sunspots are less frequent. The next solar maximum, for solar cycle 24, is predicted to occur in early 2013.

The LWS program targets specific aspects of the coupled Sun-Earth-planetary system that affects life and society and enables robotic and human exploration of the solar system. The LWS program emphasizes the science necessary to understand those aspects of the Sun and Earth's space environment that affect life and society. The ultimate goal is to provide a predictive understanding of the system, and specifically of the space weather conditions at Earth and the interplanetary medium. LWS missions are formulated to answer the specific questions needed to understand the linkages among the interconnected systems that impacts humans and society. LWS products impact technology associated with space systems, communications and navigation, and ground systems such as power grids. Its products improve understanding of the ionizing radiation environment, which has applicability to human radiation exposure in ISS, to high-altitude aircraft flight, and to future space exploration with and without human presence. Its products impact life and society by improving the definition of solar radiation for global climate change, surface warming, and ozone depletion and recovery.

For more information, please see http://science.nasa.gov/about-us/smd-programs/living-with-a-star/.

LIVING WITH A STAR (LWS)

EXPLANATION OF MAJOR CHANGES FOR FY 2013

Funding for the Solar Orbiter Collaboration project was transferred from Other Missions and Data Analysis to a unique project line because the project has entered Phase B and begun the design phase.

ACHIEVEMENTS IN FY 2011

The LWS program is making progress on the decadal survey highest priority missions. NASA successfully completed a Systems Integration Review of Radiation Belt Storm Probes and approved it to proceed to Phase D. Mission Design Review of Solar Probe Plus was successfully completed in November 2011. The project made significant progress during the first part of the formulation phase (Phase A) in advancing technology readiness levels of the major technology development efforts such as the thermal protection system, cooling system, and solar arrays. In addition, the science investigation instruments that were selected in September 2010 have been accommodated into the spacecraft reference design, and the project was well positioned to enter Phase B. Following a successful Systems Requirements Review (SRR) in June 2011 and KDP-B review in December 2011, the Solar Orbiter Collaborator project has transitioned into Phase-B. The SDO spacecraft watched a comet go behind the Sun and re-emerge for the first time during the Space Age. Until Comet Lovejoy, no Kruetz comet seen by space-based coronagraphs had been observed to survive perihelion passage. Comet Lovejoy was observed by SDO, Solar Terrestrial Relations Observatory (STEREO), Hinode, and RHESSI as it went through perihelion passage.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The SPP project plans to mature the design of the thermal protection system, to build a test system for the Technology Readiness Level 6 demonstration for the solar array cooling system, and finalize the Mission Requirements Document and the Performance Assurance Implementation Plan. Additionally, the plan includes prototyping the data bus and making performance measurements to see if they match project models, prototyping the main CPU using the Real-Time Executive for Multiprocessor Systems operating system to make sure the processor operates properly with the flight software, and developing draft interface control documents for the instruments. After a successful launch and in-orbit check out, RBSP mission operations will start in November 2012. The SOC Mission Confirmation Review (KDP-C) is planned for January 2013.

BUDGET EXPLANATION

The FY 2013 request is $232.6 million. This represents a $36.3 million increase from the FY 2012 estimate ($196.3 million).

Additional funding has been provided to SPP for its transition into the next phase (Phase B) of formulation.

LIVING WITH A STAR (LWS)

The budget for FY 2013 to FY 2016 is less than the notional amounts in the runout of the FY 2012 budget. The reduction affects future mission planning in this program. Funds were transferred to future mission planning in the STP program in accordance with the decadal NRC priorities.

RADIATION BELT STORM PROBES (RBSP)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	LCC BTC	LCC Total
FY 2013 President's Budget Request	**392.5**	**146.1**	**86.1**	**37.7**	**14.5**	**9.1**	**0.0**	**0.0**	**0.0**	**686.0**
2012 MPAR Cost Estimate	**392.5**	**146.1**	**86.1**	**37.7**	**14.5**	**9.1**	**0.0**	**0.0**	**0.0**	**686.0**
Formulation	**88.2**	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	88.2
Development/ Implementation	**304.3**	146.1	64.1	**14.6**	1.0	0.8	0.0	0.0	0.0	530.9
Operations/Close-out	**0.0**	0.0	22.0	**23.1**	13.5	8.3	0.0	0.0	0.0	66.9
Change From FY 2012 Estimate		--	--	**-48.5**						
Percent Change From FY 2012 Estimate		--	--	**-56.3%**						

The RBSP mission is designed to help us understand the Sun's influence on the Earth and near-Earth space by studying the planet's radiation belts on various scales of space and time. Understanding the radiation belt environment and its variability has extremely important practical applications in the areas of spacecraft operations, spacecraft and spacecraft system design, mission planning, and astronaut safety.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The RBSP launch date changed from May 2012 to September 2012 to accommodate slips in the Atlas launch vehicle queue.

PROJECT PURPOSE

The RBSP mission will observe the fundamental processes that energize and transport radiation belt electrons and ions in Earth's inner magnetosphere, the area in and around Earth's radiation belts. These observations will provide new knowledge on the dynamics and extremes of the radiation belts that are important to all technological systems that fly in and through geospace. RBSP will enable an understanding, ideally to the point of predictability, of how populations of relativistic electrons and penetrating ions in space form or change in response to variable inputs of energy from the Sun. The RBSP

RADIATION BELT STORM PROBES (RBSP)

Formulation	Development	Operations

mission lifetime will provide sufficient local time, altitude, and event coverage to improve understanding and determine the relative significance of the various mechanisms that operate within the radiation belts.

PROJECT PARAMETERS

The RBSP mission is comprised of two identical spacecraft in elliptical, low-inclination orbits that travel independently through Earth's radiation belts to distinguish time and space variations in the measured ions, electrons, and electric and magnetic fields. The twin spacecraft will each carry five instrument suites to observe changes in the radiation belts:

- The energetic particle, composition, and thermal plasma suite (ECT);
- The electric and magnetic field instrument suite and integrated science (EMFISIS);
- The electric field and waves suite
- The radiation belt storm probes ion composition experiment (RBSPICE); and
- The relativistic proton spectrometer (RPS).

Together, these instruments will provide the most complete set of observations of the radiation belts yet obtained.

ACHIEVEMENTS IN FY 2011

NASA successfully completed a Systems Integration Review of RBSP and approved it to proceed to Phase D. A replan was completed in August 2011 to accommodate slips in the Atlas V launch vehicle queue.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

After a successful launch and in orbit check out, mission operations will start in October 2012.

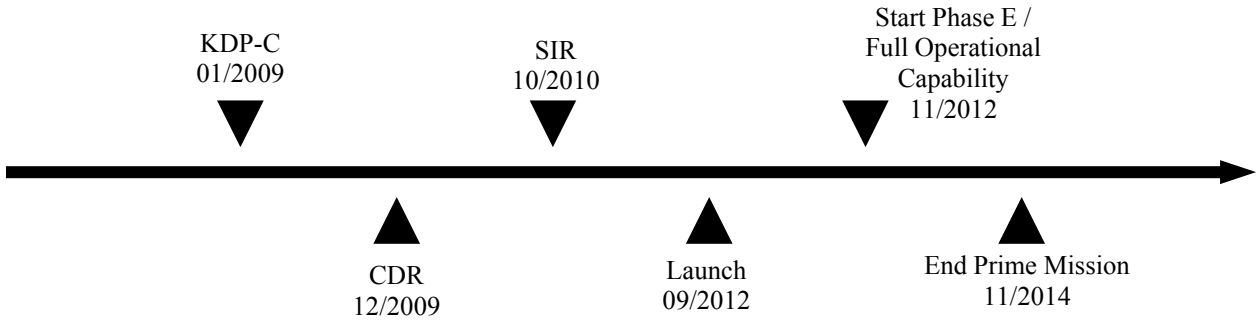
RADIATION BELT STORM PROBES (RBSP)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
KDP-C	Jan-09	Jan-09
CDR	Dec-09	Dec-09
SIR	Nov-09	Oct-10
Launch	May-12	Sep-12
Start Phase E / Full Operational Capability	Jul-12	Nov-12
End of Prime Mission	Jul-14	Nov-14

Project Schedule



RADIATION BELT STORM PROBES (RBSP)

Formulation	Development	Operations

Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2009	533.9	70 (CL)	2012	530.9	-0.6	Launch Readiness	May-12	Sep-12	4

Note: *The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. The estimate above reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as joint confidence level; all other confidence levels reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.*

Development Cost Details (in $M)

Element	Base Year Development Cost Estimate	Current Year Development Cost Estimate	Change from Base Year Estimate
TOTAL:	**533.9**	**530.9**	**-3.0**
Aircraft/Spacecraft	85.6	117.0	31.4
Payloads	95.4	102.3	6.9
Systems I&T	36.9	59.2	22.3
Launch Vehicle	133.6	132.4	-1.2
Ground Systems	16.3	22.3	6.0
Science/Technology	3.1	3.9	0.8
Other Direct Project Costs	163	93.7	-69.6

RADIATION BELT STORM PROBES (RBSP)

Formulation	Development	Operations

Project Management & Commitments

The RBSP spacecraft and ground system are being designed, developed, and tested at the JHU-APL. Instrument development participants include the University of Iowa, University of Minnesota, New Jersey Institute of Technology, and the University of New Hampshire, as well as contributions from the National Reconnaissance Office (NRO). After launch, a space weather beacon network will be established; participants at this time are South Korea and the Czech Republic. International partners will join U.S. efforts to downlink real-time RBSP space weather data for use by world space weather prediction centers.

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Ground Systems	Provider: JHU-APL Project Management: JHU-APL NASA Center: N/A Cost Share partner: N/A	Design, development, and testing	same	same
Spacecraft	Provider: JHU-APL Project Management: JHU-APL NASA Center: N/A Cost Share partner: N/A	Design, testing, and integration with instrument	same	same
Mission Operations and Data Analysis	Provider: JHU-APL Project Management: JHU-APL NASA Center: N/A Cost Share partner: Data Analysis-NRO	Spacecraft operations and data collections and assessment	same	same
Expendable Launch Vehicle	Provider: KSC Project Management: JHU-APL NASA Center: KSC Cost Share partner: N/A	Procure and provide launch vehicle and launch support	same	same

RADIATION BELT STORM PROBES (RBSP)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: the integration of the last two of six Magnetic Electron Ion Spectrometer instruments in the ECT suite is delayed, Then: the thermal vacuum testing will be delayed, reducing the schedule margin.	NASA will focus instrument experts on completing the last three Magnetic Electron Ion Spectrometer instruments and delivering them for integration.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Mission phase A-E	JHU-APL	Laurel, MD
Launch Vehicle	United Launch Alliance	Denver, CO

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
All	SRB	Oct-10	SIR recommended the project should start integration of flight articles as planned	Jun-12

SOLAR PROBE PLUS (SPP)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**71.9**	**13.9**	**49.5**	**112.1**	**103.2**	**137.1**	**229.3**	**215.2**
Change From FY 2012 Estimate		--	--	**62.6**				
Percent Change From FY 2012 Estimate		--	--	**126.3%**				

To test the survivability of the high temperatures and intense particle fluxes they will encounter, the Thermal Protection System ceramic coating was subjected to 1600 Celcius in a furnace setting and the expected mission solar flux using plasma lamps. This is to test the optical performance and survivability of the ceramic material on the carbon-carbon surface. In addition, the project has done ion exposure using a linear accelerator at 150 percent of the expected mission radiation exposure. In all testing, the system survived with no problems.

PROJECT PURPOSE

SPP will explore the Sun's outer atmosphere, or corona, as it extends out into space. Approaching 3.7 million miles from the surface of the Sun, closer than any other spacecraft, SPP will repeatedly obtain direct in-situ coronal magnetic field and plasma observations in the region of the Sun that carries the solar wind and creates space weather. This will revolutionize knowledge and understanding of coronal heating and of the origin and evolution of the solar wind, answering critical questions in heliophysics that have been ranked as the top priority by the last decadal survey. Its seven year prime mission lifetime will permit observations to be made over a significant portion of a solar cycle. Direct sampling of plasma observations that cannot be accomplished in any other way will allow heliophysicists to verify and discriminate between a broad range of theory and models that describe the Sun's coronal magnetic field and the heating and acceleration of the solar wind as well as characterize and forecast the radiation environment in which future space explorers will work and live.

For more information about SPP, please see http://nasascience.nasa.gov/missions/solar_probe.

EXPLANATION OF PROJECT CHANGES

None.

SOLAR PROBE PLUS (SPP)

Formulation	Development	Operations

PROJECT PRELIMINARY PARAMETERS

SPP's first near-Sun pass occurs three months after launch, at a heliocentric distance of 35 solar radii. Over the next several years, successive Venus gravity assist maneuvers will gradually lower the spacecraft's near-Sun pass to approximately 9.5 solar radii, by far the closest any spacecraft has ever come to the Sun. July 2018 is the earliest possible launch date within funding guidelines and technology capability. SPP will spend, during its seven year mission, a total of 27 hours inside 10 solar radii, 965 hours inside 20 solar radii, and 2,134 hours inside 30 solar radii, sampling the solar wind as it evolves with rising solar activity toward an increasingly complex structure.

ACHIEVEMENTS IN FY 2011

The project successfully completed the Mission Design Review (MDR) in November 2011, a major life cycle review that precedes Phase B of the Formulation Phase. The project made significant progress during the first part of the Formulation Phase (Phase A) in advancing technology readiness levels of the major technology development efforts such as the thermal protection system, cooling system, and solar arrays. In addition, the science investigation instruments that were selected in September 2010 have been accommodated into the spacecraft reference design, and they are well positioned to enter Phase B.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

NASA plans to mature the design of the thermal protection system to build a test system for the Technology Readiness Level 6 demonstration for the solar array cooling system, as well as finalize the Mission Requirements Document and the Performance Assurance Implementation Plan.

The plan includes prototyping the data bus and making performance measurements to see if they match project models, prototyping the main CPU using the Real-Time Executive for Multiprocessor Systems operating system to make sure the processor operates properly with the flight software, and developing draft interface control documents for the instruments.

ESTIMATED PROJECT SCHEDULE

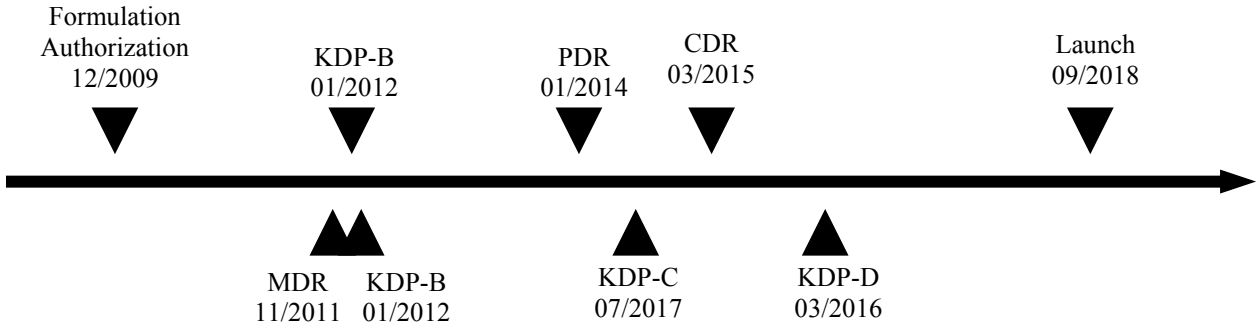
SPP will launch in July 2018 following a successful Mission Readiness Review.

SOLAR PROBE PLUS (SPP)

Formulation	Development	Operations

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
Formulation Authorization	Dec-09	Dec-09
MDR	Nov-11	Nov-11
KDP-B	Feb-12	Feb-12
KDP-B	Jan-12	Jan-12
PDR	Jan-14	Jan-14
KDP-C	Jul-14	Jul-14
CDR	Mar-15	Mar-15
KDP-D	Mar-16	Mar-16
Launch	Jul-18	Jul-18

Project Schedule



SOLAR PROBE PLUS (SPP)

Formulation	Development	Operations

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Feb-12	1,233-1,439	Launch Readiness	Jul-18

Project Management & Commitments

JHU-APL will manage the project. GSFC is responsible for program management and science management

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Instruments	Provider: NASA-funded investigators Project Management: JHU-APL NASA Center: N/A Cost Share partner: N/A	Perform in situ measurements and remote observations of the Sun	same	same
Evolved Expendable Launch Vehicle (EELV)	Provider: ULA Project Management: JHU-APL NASA Center: KSC Cost Share partner: N/A	Deliver the spacecraft to operational orbit	same	same
Ground Systems	Provider: JHU-APL Project Management: JHU-APL NASA Center: N/A Cost Share partner: N/A	Receive science and telemetry data from spacecraft, command spacecraft, and distribute science data to investigator teams	same	same
Spacecraft	Provider: JHU-APL Project Management: JHU-APL NASA Center: N/A Cost Share partner: N/A	Transport instruments to science destination, operate instruments, and modify orbit, including several Venus gravity assists	same	same

SOLAR PROBE PLUS (SPP)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: The thermal protection system design does not meet launch load requirements, Then: The mass may increase to accommodate loads, or a different design option may be required.	The project will conducted early materials testing, develop full scale prototype for test during Phase B, and allocate additional mass for the thermal protection system.

Acquisition Strategy

PIs selected through the announcement of opportunity will build science instruments. The spacecraft will be built by JHU-APL, with the spacecraft subassemblies, components, and parts competitively procured by JHU-APL. The ground system components will be defined during formulation and requirements will be defined by the project. The Phase E contracts will be managed by GSFC.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Phase B Formulation	JHU-APL	Laurel, MD

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
PDR	SRB	Nov-11	Gate review for KDP-B, successful	Jan-14

SOLAR ORBITER COLLABORATION (SOC)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**12.6**	**8.3**	**21.3**	**21.3**	**58.2**	**102.1**	**75.6**	**100.0**
Change From FY 2012 Estimate		--	--	**0.0**				
Percent Change From FY 2012 Estimate		--	--	**0.0%**				

Solar Orbiter will venture closer to the Sun than any previous mission. The spacecraft will also carry advanced instrumentation that will help untangle how activity on the sun sends out radiation, particles and magnetic fields that can affect Earth's magnetic environment, causing aurora, or potentially damaging satellites, interfering with GPS communications or even Earth's electrical power grids.

PROJECT PURPOSE

The NASA-ESA Solar Orbiter Collaboration (SOC) mission will explore the near-Sun environment to improve the understanding of the origins of the solar wind streams and the heliospheric magnetic field, the sources, acceleration mechanisms, and transport processes of solar energetic particles, and how coronal mass ejections evolve in the inner heliosphere. To achieve these objectives, in-situ measurements of the solar wind plasma, fields, waves, and energetic particles and imaging/spectroscopic observations will be made close enough to the Sun such that they are still relatively unprocessed. SOC will provide close-up views of the Sun's polar regions and its far side and will tune its orbit to the direction of the Sun's rotation to allow the spacecraft to observe one specific area for much longer than currently possible. This will provide better insight on the evolution of sunspots, active regions, coronal holes and other solar features and phenomena.

ESA is providing the spacecraft and operations, the ESA member states provide the majority of the instruments, and NASA provides the launch vehicle and two science investigations/instruments. In return for its contributions, NASA will have access to the entire science mission data set. The NASA instruments will complete formulation in early FY 2013.

For more information about SOC, please see http://nasascience.nasa.gov/missions/solar-orbiter.

SOLAR ORBITER COLLABORATION (SOC)

Formulation	Development	Operations

EXPLANATION OF PROJECT CHANGES

None.

PROJECT PRELIMINARY PARAMETERS

A NASA-provided launch vehicle will place the ESA-provided SOC spacecraft into an inner heliospheric orbit around the Sun, with perihelia ranging from 0.23 to 0.38 astronomical units and aphelia from 0.73 to 0.88 astronomical units. In the first portion of mission operations, SOC will orbit around the Sun's equator at about the same rate as the Sun's rotation. In the second portion, it will perform a Venus gravity assist between each rotation around the Sun. Each gravity assist will increase the Solar Orbiter inclination with respect to the Sun's equator so that the inclination will reach 27.5 degrees by the end of prime mission operations and 34 degrees by the end of a three-year extended mission.

ACHIEVEMENTS IN FY 2011

Following a successful Systems Requirements Review in June 2011 and KDP-B in December 2011, the project has transitioned into Phase B.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The Mission Confirmation Review (KDP-C) is planned for January 2013.

SOLAR ORBITER COLLABORATION (SOC)

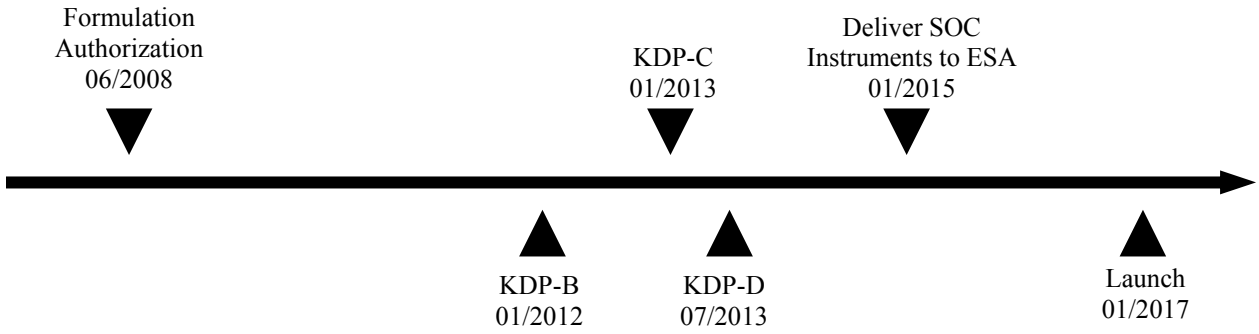
Formulation	Development	Operations

ESTIMATED PROJECT SCHEDULE

SOC will launch no earlier than January, 2017. ESA's delayed official selection of Solar Orbiter as the next mission in its Cosmic Visions program contributed to longer pre-formulation and Phase A studies.

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
Formulation	Jun-08	Jun-08
KDP-B	Jan-12	Dec-11
KDP-C	Jan-13	Jan-13
KDP-D	Jul-13	Jul-13
Deliver SOC instruments	Jan-15	Jan-15
Launch	Jan-17	Jan-17

Project Schedule



SOLAR ORBITER COLLABORATION (SOC)

Formulation	Development	Operations

Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

KDP-B Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
Dec-11	371-424	Launch Readiness	Jan-17

Project Management & Commitments

GSFC has program management responsibility for LWS and the SOC project. All instruments provided by the United States are procured through an announcement of opportunity.

Project/Element	Provider	Description	FY 2012 PB	FY 2013 PB
Solar and Heliospheric Imager (SoloHI)	Provider: Naval Research Laboratory Project Management: GSFC NASA Center: GSFC Cost Share partner: N/A	Measure the solar wind disturbances, shock formation, and turbulence.	N/A	New
Heavy Ion Sensor (HIS)	Provider: SxRI Project Management: GSFC NASA Center: GSFC Cost Share partner: N/A	Measure the heavy ions in the solar wind as part of a solar wind analysis instrument suite.	N/A	New
EELV	Provider: ULA Project Management: GSFC NASA Center: KSC Cost Share partner: N/A	Launch vehicle	N/A	New

SOLAR ORBITER COLLABORATION (SOC)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: Aggressive instrument delivery schedule is maintained by ESA, Then: NASA will not be able to meet the planned delivery schedule.	New instrument delivery and integration dates will be negotiated with ESA and project management risk resources will be used to cover the period of delay.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Launch Vehicle	United Launch Alliance	KSC, FL
SoloHI	Naval Research Laboratory	Washington, D.C.
HIS	Southwest Research Institute	Austin, TX

INDEPENDENT REVIEWS

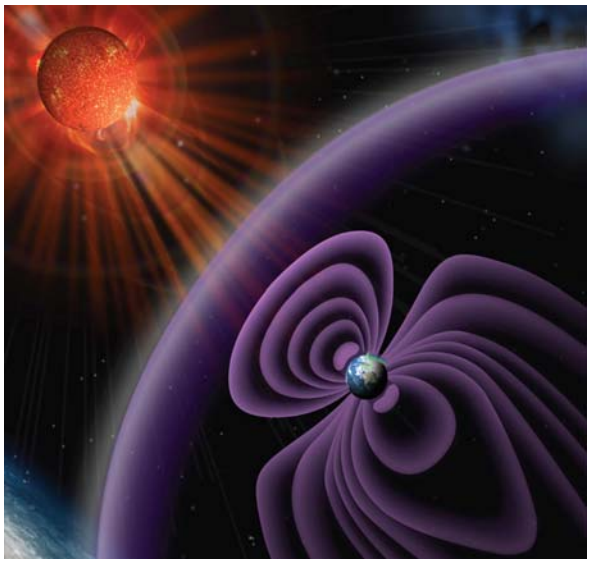
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	new	Gate review for KDP-B	Nov-12

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**50.2**	**39.3**	**61.5**	**36.3**	**37.8**	**31.8**	**36.5**
BARREL	1.6	1.6	**1.9**	1.5	0.3	0.0	0.0
Space Environment Testbeds	0.4	0.5	**0.4**	0.0	0.0	0.0	0.0
Science	17.0	15.0	**19.8**	17.5	17.5	19.8	20.8
Program Mgmt and Future Missions	9.5	7.1	**23.1**	3.1	10.4	2.4	6.0
Solar Dynamics Observatory	21.8	15.1	**16.3**	14.2	9.6	9.6	9.7
Change From FY 2012 Estimate	--	--	**22.2**				
Percent Change From FY 2012 Estimate	--	--	**56.4%**				



A magnetosphere is formed when a stream of charged particles, such as the solar wind, is deflected by the intrinsic magnetic field of a planet or similar body. Earth is surrounded by a magnetosphere, as are the other planets with intrinsic magnetic fields: Mercury, Jupiter, Saturn, Uranus, and Neptune. This complex, highly coupled system protects Earth from the worst solar disturbances. Life on Earth developed and is sustained under the protection of this variable magnetosphere.

LWS provides the opportunity to prototype and deploy space weather predictive capabilities that have far reaching applications within our society. The focus is on bringing together the complex, coupled nature of heliophysics science with the detailed observations made with the myriad of technologies deployed. This capability is essential for successful space exploration and for the increased use of complex technological systems on Earth. LWS accomplishes this goal with a combination of science missions and yearly science research grant opportunities.

LWS missions are strategically defined and prioritized by NRC decadal surveys for heliophysics. NASA uses competitive peer review and selection for science investigations, both instruments on LWS missions and science grants.

The LWS Other Missions and Data Analysis budget includes operating LWS missions, program management and limited funding for missions to be launched in the next decade.

For more information please see the LWS program at http://lws.gsfc.nasa.gov/.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Non-Operating Missions

THE BALLOON ARRAY FOR RBSP RELATIVISTIC ELECTRON LOSSES (BARREL)

BARREL is a balloon-based mission of opportunity to augment the measurements of the RBSP mission. There will be two campaigns of five to eight long-duration balloons aloft simultaneously (over one month) to provide measurements of the spatial extent of relativistic electron precipitation and to allow an estimate of the total electron loss from the radiation belts. Observations are planned for when the balloon array will be conjugate with the RBSP spacecraft, such that direct comparison is possible between them.

SPACE ENVIRONMENT TESTBEDS

The Space Environment Testbeds project will fly as a piggyback payload on the U.S. Air Force Deployable Structures Experiment mission. This will perform flight and ground investigations to characterize the space environment and its impact on hardware performance in space.

SCIENCE

The LWS Science component addresses two needs. It provides grant funding to address unresolved questions and to develop specific, comprehensive models to represent the Sun-Earth connection as a system, particularly those that have an applied space weather operational aspect. This component also provides funding to train the next generation of heliophysics expert practitioners by conducting a Heliophysics graduate-level summer school, graduate course development, and support for a limited number of space weather postdoctoral positions at universities and government laboratories.

PROGRAM MANAGEMENT AND FUTURE MISSIONS

Program Management and Future Missions provides the resources required to manage the planning, formulation, and implementation of all LWS missions. The program office provides oversight, support, and guidance to the mission teams. The office resolves technical and programmatic issues and risks, monitors and reports on progress, and is responsible for achieving overall LWS cost and schedule goals. Additionally, Future Missions supports the LWS strategic planning activities needed to address the recommendations of the heliophysics decadal survey, including the pre-formulation activities for missions that are not yet approved as projects.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

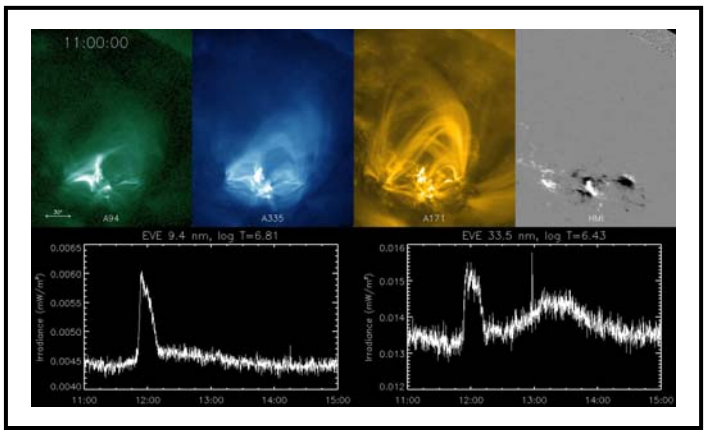
Operating Missions

SOLAR DYNAMICS OBSERVATORY (SDO)

Launched on February 11, 2010, SDO seeks to understand the Sun's influence on Earth and near-Earth space by studying the solar atmosphere on small scales of space and time and in many wavelengths simultaneously. SDO enables scientists to determine how the Sun's magnetic field is generated and structured and how stored magnetic energy is converted and released in the form of solar wind, energetic particles, and variations in the solar irradiance. SDO collects data to help elucidate how solar activity is created and how space weather emerges as a product of that activity. Measurements of the interior of the Sun, the Sun's magnetic field, the hot plasma of the solar corona, and the irradiance that creates Earth's ionosphere are the primary data products. Currently in its prime operations phase, SDO's images and spectra are key sources of data at solar science conferences and are essential in advancing knowledge of the Sun.

Recent Achievements

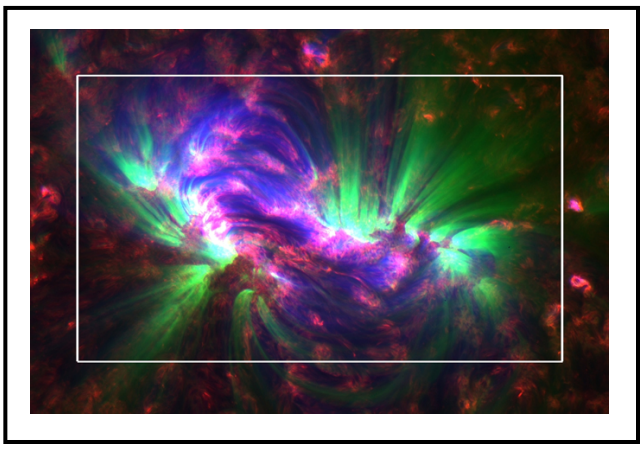
SDO SPOTS A LATE PHASE IN SOLAR FLARES



The images show a compilation of solar data from various instruments on SDO recording a flare on May 5, 2010. The images on top show the initial magnetic loops of the flare, and a delayed brightening of additional magnetic loops above the originals showing the late phase flare. Along the bottom, graphs from the Extreme Ultraviolet Variability Experiment show the extreme ultraviolet light peaking both in time with the main flare and the late phase flare. These new observations will provide a much more accurate estimate of the total energy input into the Earth's environment (ionosphere and thermosphere).

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations



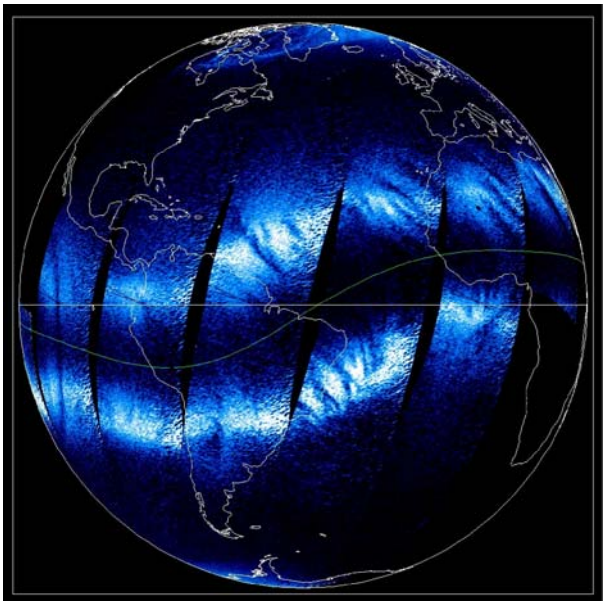
SDO SPOTS EXTRA ENERGY IN THE SUN'S CORONA

These jets, known as spicules, were captured in an SDO image on April 25, 2010. Combined with the energy from ripples in the magnetic field, they may contain enough energy to power the solar wind that streams from the Sun toward Earth at 1.5 million miles per hour.

SOLAR TERRESTRIAL PROBES (STP)

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**168.3**	**188.7**	**189.4**	**179.8**	**64.5**	**46.7**	**53.4**
Magnetospheric MultiScale	150.8	170.3	**168.3**	157.6	42.9	20.4	12.5
Other Missions and Data Analysis	17.4	18.5	**21.1**	22.2	21.6	26.3	40.9
Change From FY 2012 Estimate	--	--	**0.7**				
Percent Change From FY 2012 Estimate	--	--	**0.4%**				



The Earth's night-time ionosphere displaying spatial structures of various scales (caused by small and large-scale waves emanating upward from the troposphere). Such plasma bubbles and dropouts greatly affect communication and navigation. This program continues to make important contributions to the understanding of many of the processes that link the Earth's upper atmosphere and ionosphere system.

STP provide insight into the fundamental plasma processes inherent in all astrophysical systems. To accomplish this goal, STP investigations focus on specific scientific areas to enhance understanding of how plasma behaves in the space between the Sun and Earth. STP missions address processes such as the variability of the Sun, the responses of the planets to these variations, and the interaction of the Sun and solar system. STP missions are strategically defined and investigations are competitively selected. Strategic mission lines afford the space physics community the opportunity to plan specific missions to address important research focus areas and thus make significant progress in elucidating the fundamental processes of heliophysics.

For more information please see the STP program at http://stp.gsfc.nasa.gov/.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

No change.

SOLAR TERRESTRIAL PROBES (STP)

ACHIEVEMENTS IN FY 2011

The STP program is making progress on the decadal survey highest priority large-sized mission. In January 2012, NASA completed a Systems Integration review for the instruments on MMS, the first large-sized STP class mission. The STEREO mission celebrated five incredible years of science. Over the course of its first five years, the orbits of the two STEREO spacecraft have caused them to separate to opposite sides of the Sun. This now allows scientists to view the entire surface of the Sun for the first time.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The MMS project plans to deliver instrument suites to the observatory for integration and testing. Environmental testing on the first four observatories planned for FY 2013.

BUDGET EXPLANATION

The FY 2013 request is $189.4 million. This represents a $0.7 million increase from the FY 2012 estimate ($188.7 million).

The budget for FY 2013 to FY 2016 is more than the notional amounts in the runout of the FY 2012 budget for future mission planning. This increase is to support future missions in accordance with the soon-to-be-released heliophysics decadal survey priorities.

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	BTC	LCC Total
FY 2013 President's Budget Request	**356.8**	**150.8**	**170.3**	**168.3**	**157.6**	**42.9**	**20.4**	**12.5**	**2.9**	**1,082.6**
2012 MPAR Project Cost Estimate	**356.8**	**150.8**	**170.3**	**168.3**	**157.6**	**42.9**	**20.4**	**12.5**	**2.9**	**1,082.6**
Formulation	172.9	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	172.9
Development/ Implementation	183.8	150.8	170.3	**168.3**	157.6	26.3	0.0	0.0	0.0	857.1
Operations/close-out	0.0	0.0	0.0	**0.0**	0.0	16.6	20.4	12.5	2.9	52.4
Change From FY 2012 Estimate		--	--	**-1.9**						
Percent Change From FY 2012 Estimate		--	--	**-1.1%**						

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

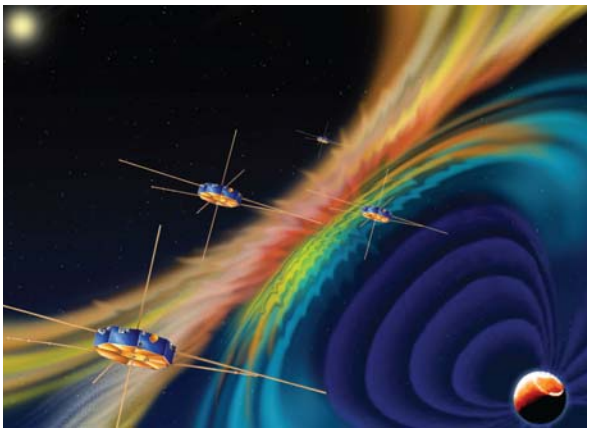
PROJECT PURPOSE

The MMS mission will use Earth's magnetosphere as a laboratory to study the microphysics of magnetic reconnection, a fundamental plasma-physical process that converts magnetic energy into heat and the kinetic energy of charged particles. In addition to seeking to solve the mystery of the small-scale physics of the reconnection process, MMS will also investigate how the energy conversion that occurs in magnetic reconnection accelerates particles to high energies and what role plasma turbulence plays in reconnection events. Magnetic reconnection, particle acceleration, and turbulence occur in all astrophysical plasma systems but can be studied in-situ only in the solar system and most efficiently in Earth's magnetosphere, where they control the dynamics of the geospace environment and play an important role in the phenomena known as "space weather."

For more information about MMS, please see http://science.nasa.gov/missions/mms/.

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations



An artist concept shows the MMS spacecraft flying through the dayside magnetic interaction region where the Sun's and Earth's magnetic fields come together. The four MMS spacecraft will fly in a tetrahedron formation, which enables the best possible measurements to identify the temporal and spatial energetic processes taking place. The scientific instruments carried onboard will rapidly measure the involved electric and magnetic fields and the tenuous, electrically charged gases or plasma. What is learned here will be extended to the Sun's atmosphere and throughout the cosmos as scientists seek to understand particle heating and acceleration throughout space.

PROJECT PARAMETERS

The MMS mission comprises four identically instrumented spacecraft that measure particles, fields, and plasmas. The MMS instrument payload will measure electric and magnetic fields and the plasmas found in the regions where magnetic reconnection occurs. Fast, multi-point measurements will enable dramatically revealing direct observations of these physical processes. The four spacecraft and instrument suites have identical design requirements. A near-equatorial orbit will explore how Sun-Earth magnetic fields reconnect in Earth's neighborhood. The four spacecraft will fly in a tetrahedron formation and the separation between the observatories will be adjustable over a range of 10 to 400 kilometers during science operations in the area of interest. The mission design life is two years.

ACHIEVEMENTS IN FY 2011

The MMS mission successfully completed its Ground System Preliminary Design Review in June 2011. The Systems Integration Review will occur in calendar year 2012.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The project will deliver four instrument suites to the observatory for integration and testing and conduct environmental testing on observatories 1 through 4. NASA will complete integration of payloads to the first of four MMS satellites.

MAGNETOSPHERIC MULTISCALE (MMS)

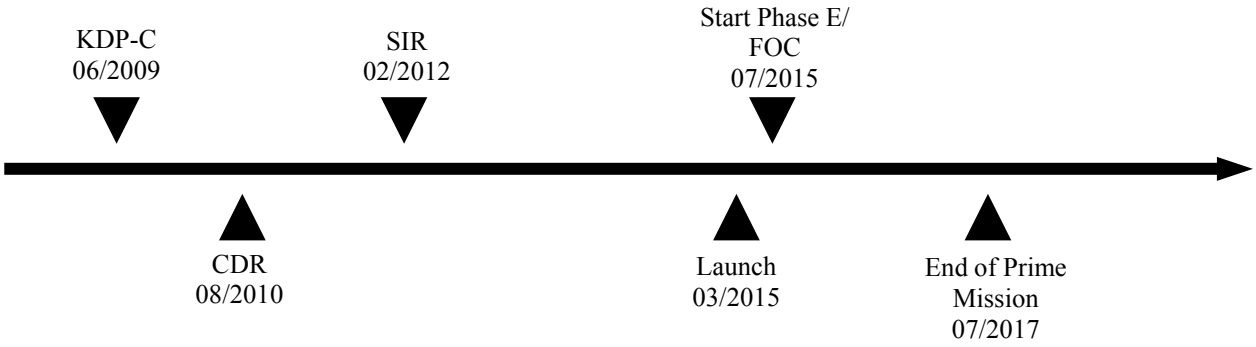
Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

The MMS mission will launch on the Atlas V 421 vehicle from Cape Canaveral Air Force Station, FL, no later than March 2015.

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
KDP-C	Jun-09	Jun-09
CDR	Aug-10	Aug-10
SIR	Jan-12	Feb-12
Launch	Mar-15	Mar-15
Start Phase E/FOC	Jul-15	Jul-15
End of Prime Mission	Jul-17	Jul-17

Project Schedule



MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Development Cost and Schedule

Base Year	Base Year Development Cost Estimate ($M)	JCL (%)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
2010	857.3	70	2012	857.3	0	Launch Readiness	Mar-15	Mar-15	0

Note: *The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. The estimate above reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as joint confidence level; all other confidence levels reflect cost confidence without necessarily factoring the potential impacts of schedule changes on cost.*

Development Cost Details (in $M)

Spacecraft costs increased due to increased requirements for FTEs, increased parts costs, and requirement for a clean room when the usual GSFC facilities were not available. Payload increases can be attributed to a foreign partner decreasing their contribution to Spin-plane Double Probe electric field instrument, fluctuation in foreign exchange rate for purchase of a major instrument component, and some cost growth for Fast Plasma Investigation, Hot Plasma Composition Analyzer, and Central Instrument Data Processor. Changes in System integration and testing and other direct project are due to reallocation of some integration and testing activity to other development elements.

Element	Base Year Development Cost Estimate	Current Year Development Cost Estimate	Change from Base Year Estimate
TOTAL:	**857.4**	**857.3**	**-0.1**
Aircraft/Spacecraft	169	192.5	23.5
Payloads	131.9	172.3	40.4
Systems I&T	55.3	31.3	-24
Launch Vehicle	194.2	192.4	-1.8
Ground Systems	19.1	21.4	2.3
Science/Technology	19.9	17.6	-2.3
Other Direct Project Costs	268	229.8	-38.2

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Project Management & Commitments

The STP Program Office at GSFC has program management responsibility for the MMS project.

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Four Instrument Suites	Provider: GSFC, SwRI Project Management: GSFC NASA Center: GSFC Cost Share partner: Austria, France, Japan	Provide measurements of electric fields, plasma wave, energetic particles, and hot plasma composition.	Same	Same
Electric fields instrument	Provider: Univ. of New Hampshire Project Management: GSFC NASA Center: GSFC Cost Share Partner: Austria	Provide measurements of electric fields (time resolution 1 ms) and magnetic fields (time resolution 10 ms)	Same	Same
Fast Plasma Investigation	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share Partner: Japan	Provide plasma wave measurements (electric vector to 100 KHz).	Same	Same
Energetic Particle Detectors	Provider: JHU-APL Project Management: GSFC NASA Center: GSFC Cost Share Partner: None	Provide high-resolution measurement of energetic particles.	Same	Same
Hot Plasma Composition Analyzers	Provider: SwRI Project Management: GSFC NASA Center: GSFC Cost Share Partner: None	Three-dimensional measurements of hot plasma composition (time resolution 10 seconds).	Same	Same
Launch Vehicle	Provider: KSC Project Management: GSFC NASA Center: KSC Cost Share partner: None	Deliver approximately 4,000 kg payload consisting of four observatories to a highly elliptical Earth orbit.	Same	Same
Ground Systems	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share Partner: None	Provide during operations minimum science data payback of four Gbits of data per observatory each day.	Same	Same

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Four Spacecraft	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share partner: None	Deliver high-rate data from instruments to ground station with a high accuracy for two years	Same	Same
Science Operations	Provider: GSFC, Univ. of Colorado, Laboratory for Atmospheric and Space Physics Project Management: GSFC NASA Center: GSFC Cost Share partner : None	Provide science data to the community and archive	Same	Same

Project Risks

Risk Statement	Mitigation
If: The GSFC environmental test facility is not available to MMS when needed, Then: Project would see increase to schedule and cost.	Decision made to proceed with MMS baseline plan of testing at the GSFC environmental facility, but MMS to protect option of thermal vacuum testing offsite.
If: Launch vehicle manifest for Atlas V launches is limited to four per year, Then: A slip in the MMS launch date would be required, leading to increased schedule and cost.	Ensure launch date is met consistent with the current Atlas V manifest.

MAGNETOSPHERIC MULTISCALE (MMS)

Formulation	Development	Operations

Acquisition Strategy

The MMS spacecraft is being designed, developed, and tested in-house at GSFC using a combination of GSFC civil servants and local contractors. The acquisition of subcontracted spacecraft sub-assemblies, components, and parts is through procurement contracts issued by the MMS procurement office. Instrument development activities are under contract with SwRI. Instrument development subcontracts include Lockheed Martin, JAXA/MEISEI, University of New Hampshire, JHU-APL, Aerospace Corporation, and a team at GSFC. The Mission Operations Center and the Flight Dynamics Operations Area will be developed and operated at GSFC using a combination of GSFC civil servants and local support service contractors. The Science Operations Center for the instruments will be developed and operated at the Laboratory for Atmospheric and Space Physics at the University of Colorado and is under contract to Southwest Research Institute.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Launch Vehicle	United Launch Alliance (ULA)	KSC, FL
Instrument Suite	SwRI	San Antonio, TX

INDEPENDENT REVIEWS

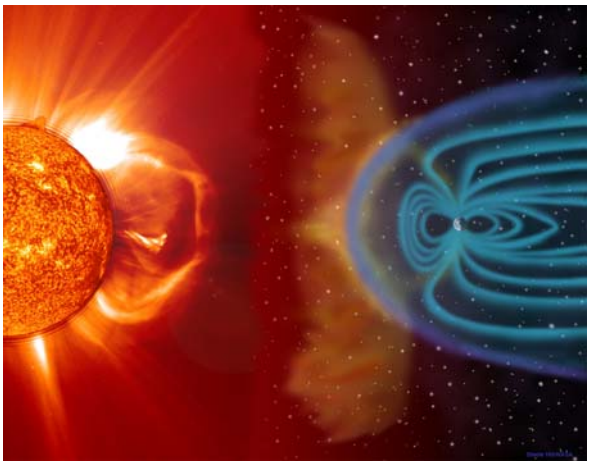
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
All	SRB	Aug-10	CDR/Successful Review	N/A
Performance	SRB	N/A	SIR	Aug-12
Performance	SRB	N/A	Key decision point-D	Oct-12
Performance	SRB	N/A	ORR	Mar-14

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**17.4**	**18.5**	**21.1**	**22.2**	**21.6**	**26.3**	**40.9**
Program Mgmt and Future Missions	1.2	1.4	**4.4**	4.1	3.5	8.0	22.6
STEREO	8.2	9.0	**8.5**	9.6	9.6	9.7	9.7
Hinode (Solar-B)	8.0	8.2	**8.2**	8.4	8.4	8.5	8.6
Change From FY 2012 Estimate	--	--	**2.6**				
Percent Change From FY 2012 Estimate	--	--	**0.1**				



Coronal mass ejections were once thought to be initiated by solar flares. Although most are accompanied by flares, it is now understood that flares and mass ejections are related phenomena, but one does not cause the other. This has important implications for understanding and predicting the effects of solar activity on Earth and in space. If a coronal mass ejection collides with Earth, it can excite a geomagnetic storm. Large geomagnetic storms have, among other things, caused electrical power outages and damaged communications satellites. Therefore, to understand and predict space weather and the effect of solar activity on Earth, a detailed understanding of the processes underlying flares, mass ejections, and geomagnetic storms is required.

The Sun, solar system, and universe consist primarily of plasma, a gas composed of ions, electrons, and neutral particles that conducts electricity and behaves distinctly different from a normal gas, liquid, or solid. Plasma strongly interacts with magnetic fields, resulting in many spectacular phenomena in space, including the auroras over Earth's polar regions.

STP missions provide the scientific basis for space weather prediction by increasing understanding of the fundamental plasma processes inherent in all the relevant astrophysical systems. STP missions address processes such as the magnetic reconnection, particle acceleration, ion-neutral interactions, and the creation and variability of magnetic dynamos.

STP missions are strategically defined and prioritized by NRC decadal surveys for heliophysics. Science investigations (i.e., instruments) on STP missions are competitively selected.

The STP Other Missions and Data Analysis budget includes operating STP missions, program management, and limited funding for future missions to be launched in the next decade.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

For more information please see the STP program at http://stp.gsfc.nasa.gov/.

Non-Operating Missions

PROGRAM MANAGEMENT AND FUTURE MISSIONS

Program Management and Future Missions provides the resources required to manage the planning, formulation, and implementation of all STP missions. The program office provides oversight, support, and guidance to the mission teams. The program office ensures successful achievement of STP program cost and schedule goals, while managing cross-project dependencies, risks, issues, and requirements as projects progress through formal key decision points. Additionally, Future Missions supports the STP strategic planning activities needed to address the recommendations of the heliophysics decadal survey, including the pre-formulation activities for missions not yet approved as projects.

Operating Missions

SOLAR TERRESTRIAL RELATIONS OBSERVATORY (STEREO)

The goal of STEREO is to understand the origin of the Sun's coronal mass ejections and their consequences for Earth. The mission consists of two spacecraft, one leading and the other lagging Earth in its orbit. STEREO's instrumentation targets the fundamental process of energetic particle acceleration in the low solar corona and in interplanetary space. The spacecraft is able to image the structure and evolution of solar storms as they leave the Sun and move out through space toward Earth.

HINODE

Hinode is a Japanese Institute of Space and Astronautical Science mission operating as a follow-on to the highly successful Japan/U.S./U.K. Yohkoh (Solar-A) collaboration. The mission consists of a coordinated set of optical, Extreme UltraViolet and x-ray instruments that are studying the basic heating mechanisms and dynamics of the active solar corona. By investigating the fundamental processes that connect the Sun's magnetic field and the solar corona, Hinode is discovering how the Sun generates magnetic disturbances and the high-energy particle storms that propagate from the Sun to Earth.

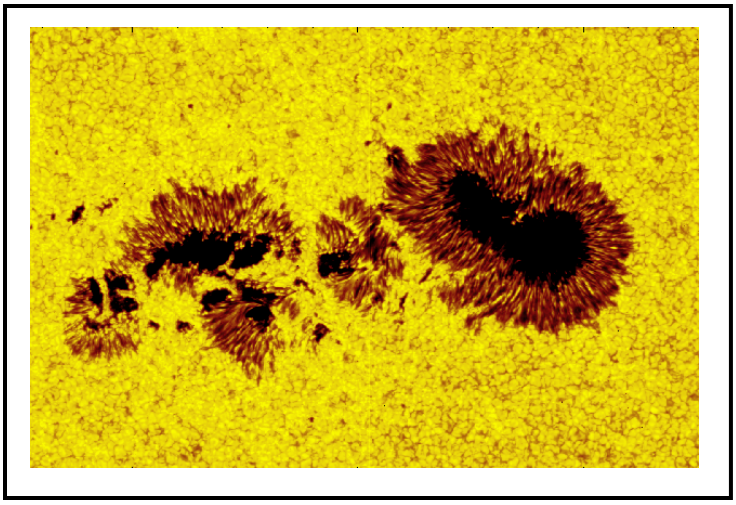
OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

STEREO MISSION CELEBRATES FIVE INCREDIBLE YEARS OF SCIENCE

In August 2011, for the first time, a spacecraft far from Earth has turned and watched a solar storm engulf our planet. The image, captured by the STEREO mission, has galvanized solar physicists, who say it could lead to important advances in space weather forecasting.



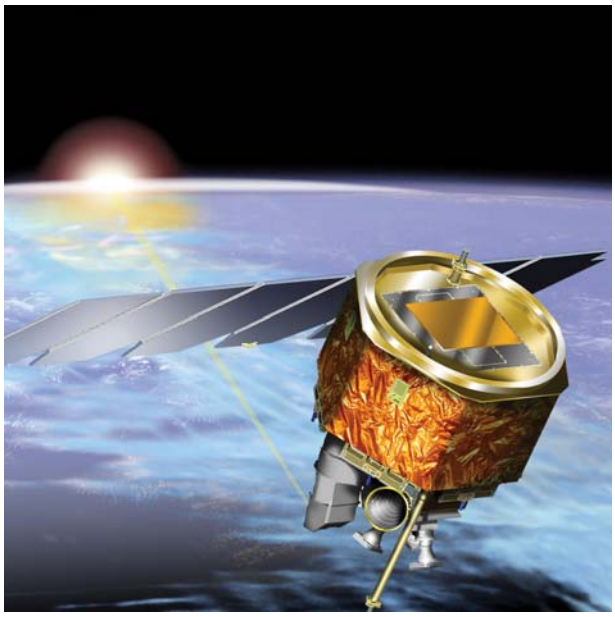
Hinode X-Class Flare

Hinode's Solar Optical Telescope zoomed in on Active Region 11263 on August 4, 2011, five days before the active region produced the largest flare of this cycle, with a peak flux more than three times larger than the previous largest flare. The actual flare was close to the edge of the Sun and not easily visible to Hinode when it occurred. Hinode discovered that the white light emissions from flares are correlated with the hard x-ray emissions.

HELIOPHYSICS EXPLORERS

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**91.7**	**60.2**	**46.1**	**88.4**	**117.5**	**84.8**	**84.8**
IRIS	63.5	39.1	**12.1**	7.3	1.2	0.0	0.0
Other Missions and Data Analysis	28.1	21.1	**34.0**	81.1	116.3	84.8	84.8
Change From FY 2012 Estimate	--	--	**-14.1**				
Percent Change From FY 2012 Estimate	--	--	**-23.4%**				



NASA's Aeronomy of Ice in the Mesosphere (AIM) satellite is a SMEX-class mission that remotely senses night-shining clouds in the mesosphere. These noctilucent clouds are made of ice crystals that form over the summer poles at an altitude too high and a temperature too cold for water-vapor clouds. Recent results from the mission have provided evidence of change in the behavior of these noctilucent clouds, with the data showing dramatically lower ice content. This is leading scientists to speculate about changes in weather conditions and pole-to-pole atmospheric circulation, and whether these changes are driven by the solar cycle.

The Heliophysics Explorers program provides frequent flight opportunities for world-class scientific investigations from space to address heliophysics space science goals. These investigations target very focused science topics that augment, replace, or redirect strategic line missions. The mission results fill important science gaps in the prescribed program. Highly competitive selection ensures that the most current and best strategic science will be accomplished.

Full missions can either be medium explorer (MIDEX), explorers (EX), or small explorers (SMEX). Missions of opportunity space science investigations are typically instruments flown as part of a non-NASA space mission. SMEX's are the smallest explorer mission. MIDEX are larger with greater scope.

EX class missions are solicited through Explorer Announcements of Opportunity. NASA selected three EXs and three MOs heliophysics missions for initial study from the current Announcements of Opportunity. In FY 2013, NASA will down select these to one or two final missions for implementation.

The Explorers program selected IRIS in 2009. IRIS is a small explorer mission, currently in the development phase and scheduled for launch in FY 2013.

HELIOPHYSICS EXPLORERS

Other Missions and Data Analysis supports numerous operating Heliophysics Explorer missions, as well as program management functions and funding for future mission selections.

For more information on Explorer missions, please see http://explorers.gsfc.nasa.gov/missions.html.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

Beginning in FY 2012, the Explorers program is budgeted as two unique programs, Heliophysics Explorers and Astrophysics Explorers. The Heliophysics and Astrophysics Explorers will have different cadences for Announcement of Opportunity releases.

ACHIEVEMENTS IN FY 2011

The Heliophysics Explorers program received 16 submitted proposals in response to the Explorer 2011 Announcement of Opportunity. The program also received nine proposals for Science Missions of Opportunity; and eight solicitations were received for Explorers U.S. Participating Investigators (Explorer USPI). As a result of the September 2011 Explorers program selections, three Explorer mission proposals and three mission of opportunity proposals were selected to conduct Phase-A studies. Additionally, three solicitations were selected for Explorer USPI missions.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

IRIS is expected to complete Pre-Ship Review in October and Flight Readiness Review in November 2012. The current launch readiness date is scheduled no later than June 2013. The next Heliophysics Explorer mission selection is currently planned for 2013.

BUDGET EXPLANATION

The FY 2013 request is $46.1 million. This represents a $14.1 million decrease from the FY 2012 estimate ($60.2 million).

The IRIS project workforce will decrease as launch in June 2013 nears. The Heliophysics Explorers Future Mission budget ramps up for the start of the missions that were selected from the current Announcement of Opportunity.

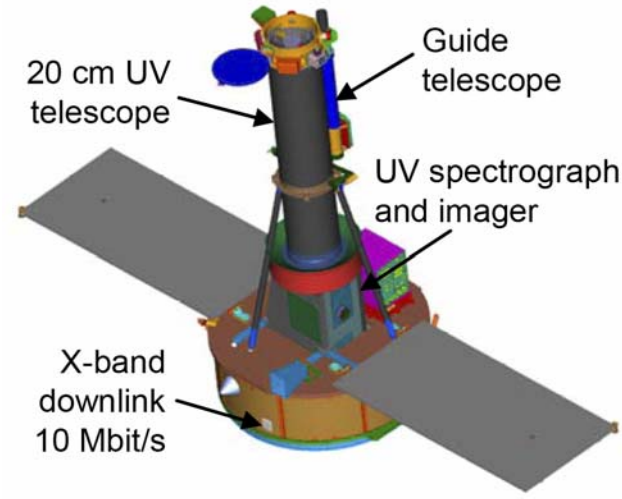
The budget for FY 2013 to FY 2016 is slightly less than the notional amounts in the runout of the FY 2012 budget, reflecting the split of the Heliophysics Explorers management budget between Astrophysics and Heliophysics.

INTERFACE REGION IMAGING SPECTROGRAPH (IRIS)

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**57.0**	**63.5**	**39.1**	**12.1**	**7.3**	**1.2**	**0.0**	**0.0**
Change From FY 2012 Estimate		--	--	**-27.0**				
Percent Change From FY 2012 Estimate		--	--	**-69.1%**				



IRIS will contribute to our fundamental understanding of the solar energy transport, will increase our ability to forecast space weather, and will deepen our understanding of distant astrophysical phenomena. A launch in 2013 during solar maximum places IRIS in a unique configuration of supporting instruments like SDO, Hinode, SOLIS, SST, and IBIS that observe from the solar surface to the global corona. This combination, with ground-based observations and numerical simulations, will deliver a breakthrough in our understanding of the energization and dynamics of the solar atmosphere.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

None.

PROJECT PURPOSE

IRIS explorer will help scientists understand how the solar atmosphere is energized. The IRIS investigation combines advanced numerical modeling with a high resolution UV imaging spectrograph. IRIS will obtain UV spectra and images with high resolution in space and time focused on the chromosphere and transition region of the Sun, a complex interface region between the photosphere and corona. In this region, all but a few percent of the non-radiative energy leaving the Sun is converted into heat and radiation. Here, magnetic field and plasma exert comparable forces, resulting in a dynamic region whose understanding remains a challenge. IRIS fills a crucial gap in our ability to advance Sun-Earth connection studies by tracing the flow of energy and plasma through this foundation of the corona and heliosphere.

This SMEX mission was selected in June 2009 and is expected to launch in June 2013. The unique instrument capabilities, coupled with state of the art three-dimensional modeling, will fill a large gap in knowledge of this dynamic region of the solar atmosphere. The mission will complement and greatly

INTERFACE REGION IMAGING SPECTROGRAPH (IRIS)

Formulation	Development	Operations

extend the scientific return of the Heliophysics System Observatory, as this fleet of spacecraft follows the effects of energy release from the Sun to Earth.

For more information, please see: http://science.nasa.gov/missions/iris/.

PROJECT PARAMETERS

IRIS is a three-axis stabilized, sun-pointed mission that studies the chromosphere in the far ultraviolet and near ultraviolet with 0.33 arcsecond spatial resolution, 0.4 kilometers per second velocity resolution, and a field of view of 171 arcsec. This two-year mission fills a critical observational data gap by providing simultaneous, co-spatial and comprehensive coverage from photosphere (about 4,500K) up to corona (≤ 10 meter kelvin). IRIS consists of a 20 centimeter aperture telescope assembly that feeds an imaging spectrograph and a separate imaging camera system with wavelengths in the far ultraviolet and near ultraviolet. A spacecraft bus based upon heritage designs supports the science mission and provides pointing, power, and data communications for the mission. The launch vehicle is an Orbital Sciences Corporation Pegasus XL with launch operations out of Vandenberg Air Force Base in CA.

ACHIEVEMENTS IN FY 2011

The IRIS project held a successful Critical Design Review in December 2010. The spectrograph structure for IRIS was ready and the magnetometer was delivered in October 2011.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

Upon successful review, IRIS expects to enter Phase D (design and development phase) in May 2012. During FY 2013, IRIS is expected to complete Pre-Ship Review in October and Flight Readiness Review in November of 2012. The current launch readiness date is scheduled in June 2013.

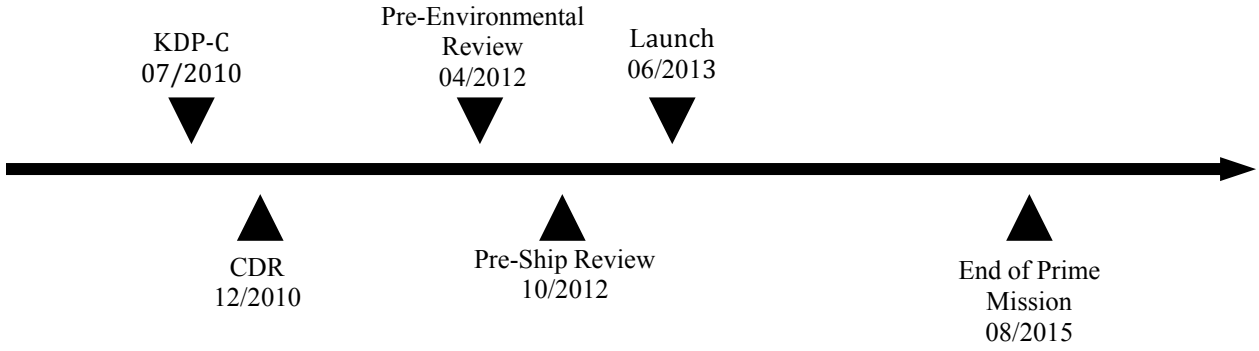
INTERFACE REGION IMAGING SPECTROGRAPH (IRIS)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
KDP-C	Jul-10	Jul-10
CDR	Dec-10	Dec-10
Pre-Environmental Review	Dec-11	Apr-12
Pre-Ship Review	Sep-12	Oct-12
Launch	Jun-13	Jun-13
End of Prime Mission	Aug-15	Aug-15

Project Schedule



INTERFACE REGION IMAGING SPECTROGRAPH (IRIS)

Formulation	Development	Operations

Project Management & Commitments

IRIS is a principal investigator-managed project. Lockheed Martin is leading the formulation and implementation of the project. The IRIS science investigation includes scientists and engineers from Lockheed Martin, ARC, and GSFC. GSFC program office is responsible for oversight and science management including transitioning into the operations phase.

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Instrument	Provider: Lockheed Martin Project Management: GSFC NASA Center: GSFC, ARC Cost Share partner: None	Major components of instrument: science telescope and spectrograph	Same	Same
Launch Vehicle	Provider: KSC Project Management: GSFC NASA Center: KSC Cost Share partner: None	Pegasus XL	Same	Same
Spacecraft	Provider: Lockheed Martin Project Management: GSFC NASA Center: GSFC, ARC Cost Share partner: None	Subsystems include: comm system, S-band, X-band antennae, solar array mechanics, star tracker	Same	Same
Mission Operations	Provider: ARC Project Management: GSFC NASA Center: ARC Cost Share partner: None	ARC to provide two years of mission operations	Same	Same

INTERFACE REGION IMAGING SPECTROGRAPH (IRIS)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: There is an in-flight failure in the single string design of the IRIS spacecraft, Then: there is no ability to switch over to a redundant component.	Consistent with higher risks SMEX mission, single string risks are mitigated by use of proven designs, high reliability parts, additional testing of critical systems, and testing of development models as early as possible.
If: The transponder and reaction wheel vendors continue to experience problems during development, Then: the spacecraft integration and testing will be impacted.	Additional program manager and subject matter expert oversight has been assigned. Engineering units are being used as a pathfinder for manufacturing and test and will be available for early testing.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Development of spacecraft and the integration and testing of the complete IRIS satellite system through on-orbit commissioning	Lockheed Martin	Palo Alto, CA

INDEPENDENT REVIEWS

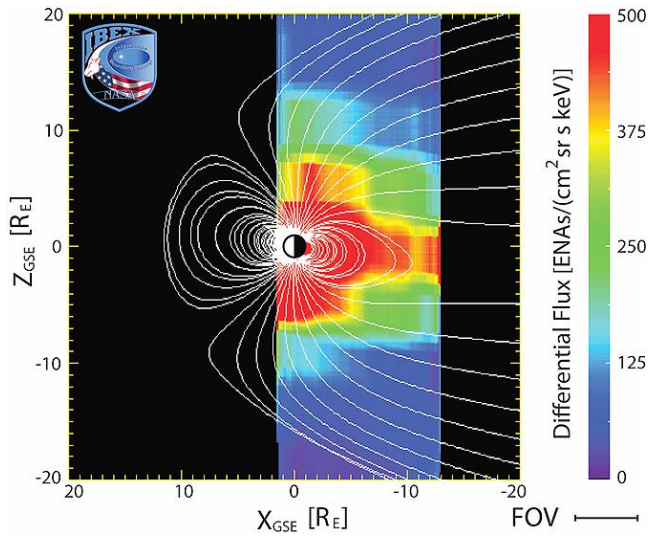
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
All	SRB	Dec-10	Critical Design Review – Successful	N/A
All	SRB	N/A	System Integration Review	Apr-12
All	SRB	N/A	Operation Readiness Review	Oct-12

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**28.1**	**21.1**	**34.0**	**81.1**	**116.3**	**84.8**	**84.8**
Program Management and Future Missions	0.0	3.8	**14.9**	63.5	101.0	65.5	65.6
Explorer Management	10.1	4.7	**6.0**	6.2	6.2	6.4	6.4
IBEX	1.5	1.6	**4.0**	2.5	2.5	4.0	4.0
TWINS	1.0	1.0	**1.0**	0.6	0.6	0.6	0.6
CINDI	1.3	1.0	**0.8**	0.8	0.1	0.0	0.0
AIM	3.5	3.0	**3.0**	3.1	3.0	3.0	3.0
THEMIS/ARTEMIS	10.9	6.0	**4.4**	4.6	3.0	5.2	5.2
Change From FY 2012 Estimate	--	--	**12.9**				
Percent Change From FY 2012 Estimate	--	--	**61.2%**				



This image, from the IBEX mission, shows the structure of magnetic field lines as they interact and explosively release energy in the plasma sheet of the Earth's geomagnetic tail. Based upon this mission and its revolutionary camera technology, future NASA science missions may be able to make high definition videos of the development of space weather systems around the Earth, eventually enabling space weather prediction much like Earth weather prediction.

Explorer missions offer the ability to meet the full range of heliophysics science identified as being vital and urgent by the NRC decadal surveys. These missions are designed to be lower cost and have a short development cycle; they provide smaller, focused science investigations to supplement the larger strategic mission lines.

The Heliophysics Explorers Other Missions and Data Analysis budget includes operating Explorer missions, program management and funding for a mission currently in the competitive principal investigator-led mission procurement cycle.

For more information, see the Explorer program at http://explorer.gsfc.nasa.gov/.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Non-Operating Missions

PROGRAM MANAGEMENT AND FUTURE MISSIONS

Program Management and Future Missions provides the resources required to manage the planning, formulation, and implementation of all Explorer missions. The program office provides oversight, support, and guidance to the mission teams. The program office ensures successful achievement of Explorer program cost and schedule goals, while managing cross-project dependencies, risks, issues, and requirements as projects progress through formal key decision points. Additionally, Future Missions supports the Explorer procurement activities including the pre-formulation activities for missions not yet approved as projects.

The Explorer program has selected six science proposals for evaluation as potential future science missions. Following detailed mission concept studies, one of the full mission concepts and/or one-or-more of the mission of opportunity concepts would be selected in February 2013 to proceed toward flight with launches potentially in 2016 and/or 2018. FY 2013 funding supports the six Phase A concept studies. On selection, FY 2014 to FY 2018 funding would be moved to unique project lines.

EXPLORER MANAGEMENT

Explorer Management encompasses the program office resources required to manage the formulation and implementation of all Explorer projects. The program office is responsible for providing support and guidance to projects in resolving technical and programmatic issues and risks, for monitoring and reporting technical and programmatic progress of the projects and for achieving Explorer cost, schedule and technical goals and requirements.

Operating Missions

INTERSTELLAR BOUNDARY EXPLORER (IBEX)

IBEX is the first mission designed to detect the edge of the Solar System. As the solar wind from the sun flows out beyond Pluto, it collides with the material between the stars, forming a shock front. These interactions create energetic neutral atoms, particles with no charge that move very quickly. This region emits no light that can be collected by conventional telescopes so, instead, IBEX, measures the particles that happen to be traveling inward from the boundary. IBEX contains two detectors designed to collect and measure energetic neutral atoms, providing data about the mass, location, direction of origin, and energy of these particles. From this data, maps of the boundary are created. IBEX's sole, focused science objective has been to discover the nature of the interactions between the solar wind and the interstellar medium at the edge of our solar system.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

TWO WIDE-ANGLE IMAGING NEUTRAL ATOM SPECTROMETERS (TWINS)

TWINS is a NASA-sponsored mission of opportunity that has been operational since 2008 and approved for extended operations until September 2014. TWINS provides stereo imaging of the Earth's magnetosphere, the region surrounding the planet controlled by its magnetic field and containing the Van Allen radiation belts and other energetic charged particles. TWINS gives a three-dimensional global visualization of this region, which has led to a greatly enhanced understanding of the connections between different regions of the magnetosphere and their relation to solar variability.

THE COUPLED ION-NEUTRAL DYNAMICS INVESTIGATIONS (CINDI)

CINDI is a mission to understand the dynamics of the Earth's ionosphere, and consists of two instruments on the Communication/Navigation Outage Forecast System satellite, a project of the U.S. Air Force. This mission studies the behavior of equatorial ionospheric irregularities which can cause significant service interrupts for communications and navigation systems. CINDI is in extended phase until September 2014.

AERONOMY OF ICE IN THE MESOSPHERE (AIM)

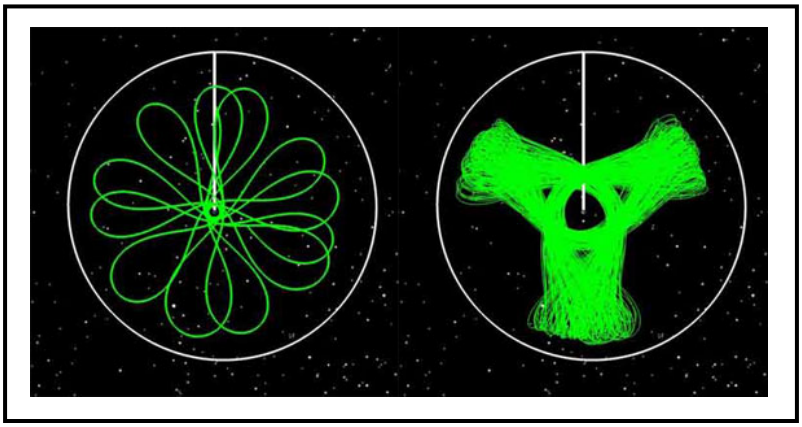
AIM is a mission to determine why polar mesospheric clouds form and why they vary. Polar mesospheric clouds, Earth's highest-altitude clouds, form in the coldest part of the atmosphere about 50 miles above the polar regions every summer. These clouds are of particular interest, as the number of clouds in the middle atmosphere (mesosphere) over the Earth's poles has been increasing over recent years, and they are thought to be related to climate change. AIM launched on April 25, 2007, completed its prime mission in FY 2009, and is currently in extended phase until September 2014.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

TIME HISTORY OF EVENTS AND MACROSCALE INTERACTIONS DURING SUBSTORMS (THEMIS) AND ACCELERATION, RECONNECTION, TURBULENCE AND ELECTRODYNAMICS OF THE MOON'S INTERACTION WITH THE SUN (ARTEMIS)

THEMIS is a MIDEX mission that launched on February 17, 2007, and is currently operating in extended phase until September 2014. Starting as a five-spacecraft mission, the three inner probes now focus on collecting data related to the onset and evolution of magnetospheric substorms, while the two outer probes (now referred to as ARTEMIS) have been repositioned into lunar orbits (see below). Magnetospheric substorms are the explosive release of stored energy within the near-Earth space environment leading to important space weather effects. The two ARTEMIS probes orbit the Moon's surface at approximately one hundred miles altitude and provide new information about the Moon's internal structure and its surface composition. THEMIS and ARTEMIS, among others in the heliophysics portfolio, are examples of missions offering important dynamics knowledge useful for future human spaceflight.



Recent Achievements

IBEX

IBEX discovered a ribbon of energetic neutral atoms, created by the collision of solar winds and particles and fields from interstellar space that were not predicted by any model or theory. IBEX began measurements in 2008 during a quiet period of solar activity. Researchers have recently adjusted the IBEX orbit to be more stable over the remainder of its lifetime. IBEX's first few oval orbits (depicted on left) and predicted orbits over the next decade (depicted on right), will allow measurements over the full solar cycle with less background noise and therefore better confidence in the signal.

OTHER MISSIONS AND DATA ANALYSIS

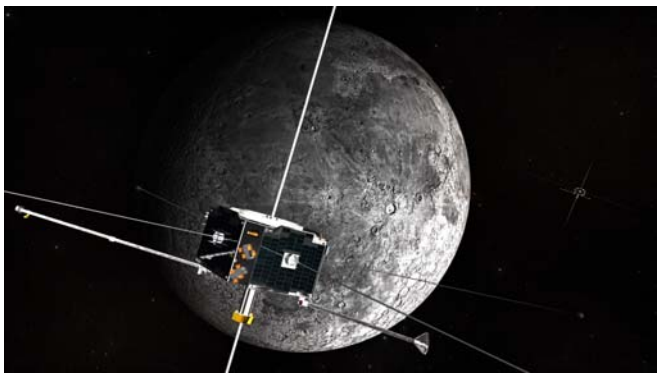
Formulation	Development	Operations

NOCTILUCENT CLOUD SEASON BEGINS

In recent years, AIM has collected data on noctilucent clouds appearing at ever lower in latitudes, but just why they form is not yet known. The clouds are seasonal, appearing most often in late spring and summer.

NASA studies these clouds in order to better understand our lower atmosphere and how it is connected to weather and climate.

THEMIS - ARTEMIS SECOND PROBE FINALLY ARRIVES AT ITS NEW HOME



On July 17, 2011 the second probe of the ARTEMIS mission successfully entered orbit around the Moon after a circuitous two-year journey from Earth orbit. Shortly after the two probes completed their original mission studying Earth's magnetic field in 2009 (THEMIS), they were propelled using carefully designed gravity-assist maneuvers to farther and farther orbits. In order to continue to use the probes for scientific studies, the two spacecraft were moved to the Moon's Trojan points, on either side of the moon. The two ARTEMIS probes were the first spacecraft ever to use those complex orbits operationally. Knowledge of operations at Lagrangian points and understanding the environments there provides information valuable for future human space travel.

After using the Lagrange orbits as observational outposts for nine months, the two spacecraft were subsequently staged to enter into stable lunar orbits. The P1 probe entered lunar orbit on June 27, 2011. The two probes are orbiting the Moon in opposite directions enabling, the pair's sensitive instruments to yield the first three-dimensional measurements of the moon's magnetic field, and ultimately allowing scientists to determine its regional influence on solar wind particles.