ASTROPHYSICS

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	**631.1**	**672.7**	**659.4**	**703.0**	**693.7**	**708.9**	**710.2**
Astrophysics Research	146.9	164.1	**176.2**	189.1	205.1	211.5	218.7
Cosmic Origins	229.1	237.3	**240.4**	228.5	215.1	205.3	205.7
Physics of the Cosmos	108.7	108.3	**111.8**	109.6	96.3	92.7	74.6
Exoplanet Exploration	46.4	50.8	**56.0**	41.6	43.3	42.4	45.6
Astrophysics Explorer	100.0	112.2	**75.1**	134.3	133.9	157.0	165.6

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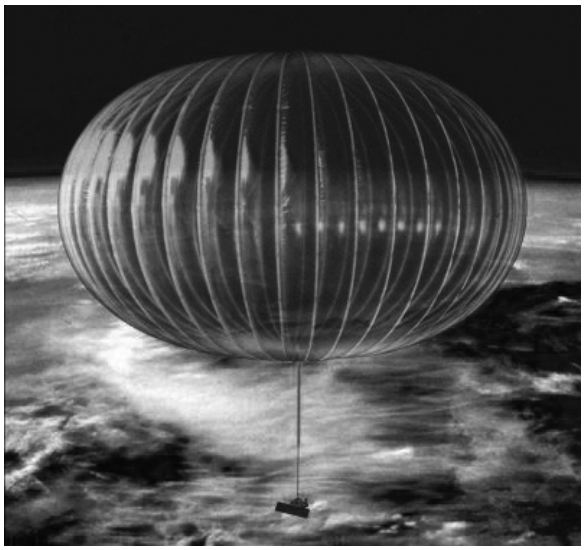
ASTROPHYSICS RESEARCH

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	**146.9**	**164.1**	**176.2**	**189.1**	**205.1**	**211.5**	**218.7**
Astrophysics Research and Analysis	59.6	64.6	**64.2**	65.5	66.8	68.2	69.5
Balloon Project	26.8	31.6	**31.3**	31.2	32.8	34.2	34.3
Other Missions and Data Analysis	60.5	67.9	**80.6**	92.3	105.4	109.2	114.8
Change From FY 2012 Estimate	--	--	**12.1**				
Percent Change From FY 2012 Estimate	--	--	**7.4%**				



Large unmanned helium balloons provide NASA with an inexpensive means to place payloads into a space environment. Scientific ballooning has contributed significantly to NASA's science program, both directly with science coming from measurements made by balloon-borne instruments, and indirectly by serving as a test platform on which instruments have been developed that were subsequently flown on NASA space missions.

The Astrophysics Research program provides funding to analyze the data from NASA missions to understand astronomical events such as the explosion of a star, the birth of a distant galaxy, or the motion of planets around their parent stars. The program also enables the early development of new technologies for future missions, and suborbital flights of experimental payloads on balloons and sounding rockets.

The program facilitates basic research for scientists to work out the consequences of their theories, and to understand how they can best use data from NASA missions to develop new knowledge about the cosmos.

For more information on the Astrophysics Research program, see http://nasascience.nasa.gov/researchers/sara/.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

Additional funds in FY 2013 will support operating mission extensions as recommended by the Senior Review.

ASTROPHYSICS RESEARCH

ACHIEVEMENTS IN FY 2011

In FY 2011, the Astrophysics Research program changed its emphasis to enhance development of optics, detectors, and other key technologies for use in future missions. During the year, NASA received 677 proposals for competitive research awards, 21 percent more than in FY 2010. NASA announced a new technology fellowship program, that will develop early career researchers who can lead future astrophysics flight instruments, projects, and missions.

The Balloon program conducted 18 scientific balloon launches during five campaigns from the U.S., Sweden, Australia, and Antarctica, including Balloon-borne Large Aperture Sub-millimeter Telescope for Polarization, which circled Antarctica for ten days, mapping sub-millimeter radiation from extremely distant galaxies. In a 22 day flight over Antarctica, NASA successfully tested a super-pressure balloon that can allow months-long flights. Two high altitude student payload missions were flown, each carrying 12 payloads, and involved 95 students from 14 institutions in 10 states and Puerto Rico.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, NASA will review and extend operating missions per the recommendations of the 2012 Senior Review process. The Senior Review is a bi-annual review of all operating missions that have, or are about to, successfully complete their prime mission operations phase.

In the competed research programs, NASA plans to maintain the same level funding level for suborbital payloads, for laboratory astrophysics, and for the Astrophysics Theory Program.

Three long duration balloon flights are planned from Antarctica, carrying experiments to measure the cosmic rays that fill the Milky Way, and to map the tiny fluctuations in the cosmic microwave background that are the seeds of the largest cosmic structures. A fourth experiment could also be flown on the super-pressure balloon. An advanced pointing system that can stabilize a balloon borne telescope to better than an arc-second should be ready for use, enabling observations of planets in our own solar system and those circling other stars.

BUDGET EXPLANATION

The FY 2013 request is $176.2 million. This represents a $12.1 million increase from the FY 2012 estimate ($164.1 million). Additional funds will support extended mission operations, as recommended by the 2012 Senior Review.

ASTROPHYSICS RESEARCH

Projects

RESEARCH AND ANALYSIS

This project supports basic research, solicited through NASA's Research Opportunites in Space and Earth Sciences (ROSES)-2012 announcement. NASA solicits investigations relevant to the Astrophysics programs over the entire range of photon energies, gravitational waves, and particles of cosmic origin. Scientists and technologists from a mix of disciplines review proposals and make merit based selections.

The Astrophysics Research and Analysis program (APRA) solicits detector and technology development for instruments that may be candidates for future space flight opportunities, and science and technology investigations using sounding rockets, high-altitude balloons, and similar platforms. The first step in developing a new technology for future NASA missions is to show that it can work in the laboratory. A new type of scientific instrument is often flown first on a stratospheric balloon mission, or on a sounding rocket flight that takes it briefly outside Earth's atmosphere. Instruments for balloons and sounding rockets are not as costly as those for an orbital mission, and they can be built quickly to respond to unexpected opportunities. The equipment is usually retrieved after the flight, so that novel instruments can be tested, improved, and flown again. These suborbital flights are important in training the next generation of scientists and engineers to better compete in the 21st century, and to maintain U.S. leadership in science, engineering, and technology. APRA also supports laboratory astrophysics and limited ground-based observations.

The Astrophysics Theory Program (ATP) solicits basic theory investigations needed to interpret data from NASA's space astrophysics missions, and to develop the scientific basis for future missions. Astrophysics Theory topics are fundamental ones: star formation; supernova explosions and gamma-ray bursts; the birth of the galaxies; dark matter, dark energy and the cosmic microwave background.

In FY 2011, NASA created a new Technology Fellowship in Astrophysics to develop early career researchers who could lead future astrophysics flight instruments, projects and missions. A first cohort of fellows will be chosen in FY 2012.

In FY 2013, the Research and Analysis program will support a vigorous enabling technology program of laboratory astrophysics, to improve state-of-the-art detector technology.

BALLOONS

The Balloons project is managed out of the Wallops Flight Facility. The project offers inexpensive, high-altitude flight opportunities for scientists to conduct research and test new technologies prior to spaceflight application. Balloon experiments cover a wide range of disciplines in astrophysics, solar and heliospheric physics, as well as Earth upper-atmosphere chemistry. Observations from balloons have even detected echoes of the Big Bang, and probed the earliest galaxies. The Balloons project continues to work to increase balloon size and enhance capabilities, including an accurate pointing system to allow detection of planets around other stars, and a super pressure balloon that maintains the balloon's integrity at a high altitude to allow much longer flights.

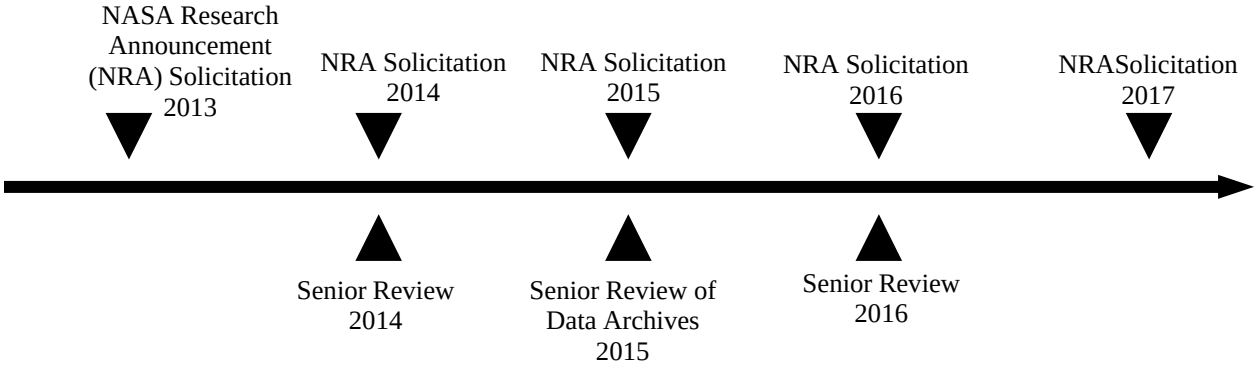
ASTROPHYSICS RESEARCH

In FY 2011, the project flew two high altitude student payload missions, each carrying 12 payloads involving 95 students from 14 institutions in ten states and Puerto Rico.

In FY 2013, three long-duration balloon flights are planned from Antarctica, carrying experiments to measure the cosmic rays that fill the Milky Way, and to map the tiny fluctuations in the cosmic microwave background that are the seeds of the largest cosmic structures. A fourth experiment could be flown on the super-pressure balloon. An advanced pointing system that can stabilize a balloon-borne telescope to better than an arc-second should be ready for use, enabling observations of planets in our own solar system and those circling other stars.

Program Schedule

The program issues solicitations every year. A Senior Review process assesses all missions in the extended operations phase every two years, and all data archives every four years.



ASTROPHYSICS RESEARCH

Program Management & Commitments

Project/Element	Provider
Research and Analysis Project	Provider: All NASA Centers Project Management: HQ (SMD) NASA Center: All Cost Share: None
Balloon Project	Provider: WFF Project Management: GSFC and WFF NASA Center: GSFC Cost Share: N/A

Acquisition Strategy

Solicitations go out through ROSES-2012 competition every year. A Senior Review process reviews all missions in extended operations phase every two years, and all data archives every four years.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Balloon Management	New Mexico State University Balloon Factory	Palestine, TX

ASTROPHYSICS RESEARCH

INDEPENDENT REVIEWS

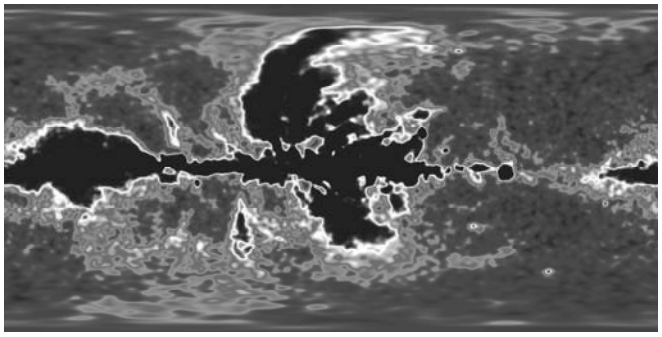
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Mission Senior Review Panel	Apr-10	A comparative evaluation of Astrophysics operating missions. A report ranking the operating missions will be released	2012, 2014
Quality	Archives Senior Review Panel	May-11	A comparative evaluation of Astrophysics data archives. A report evaluating the value of each archive will be released.	2015

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	**60.5**	**67.9**	**80.6**	**92.3**	**105.4**	**109.2**	**114.8**
Directed Research and Technology	0.0	0.0	**0.0**	3.3	5.2	5.6	6.4
Keck Single Aperture	2.2	2.3	**2.4**	2.4	2.5	2.5	2.5
Directorate Support	10.1	13.7	**13.5**	13.9	14.0	14.5	14.5
Education and Public Outreach	13.2	15.4	**10.1**	10.1	10.1	10.1	10.1
Astrophysics Senior Review	0.0	0.0	**16.3**	24.5	33.5	35.2	40.0
ADP	14.1	16.3	**18.3**	18.5	18.5	19.1	19.1
Astrophysics Data Curation and Archival	20.8	20.1	**20.0**	19.6	21.7	22.1	22.2
Change From FY 2012 Estimate	--	--	**12.7**				
Percent Change From FY 2012 Estimate	--	--	**0.2**				



Astrophysics archives make mission data available to all researchers. For example, researchers used Wilkinson Microwave Anisotropy Probe data to produce this sky map of the polarized portion of the cosmic microwave background signal.

AstrophysicsResearch programs prepare for the next generation of missions through both theoretical research and applied technology investigations. They also use data from current missions and use suborbital science investigations to advance NASA science goals. The ultimate goal is to create new knowledge as explorers of the universe, and to use that knowledge for the benefit of all humankind.

Non-Operating Missions

DIRECTED RESEARCH AND TECHNOLOGY

This project funds the civil service staff that will work on emerging Astrophysics projects, instruments and research. The workforce and funding will transfer to projects by the beginning of FY 2014.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

KECK SINGLE APERTURE (KSA)

KSA manages NASA time on the 10 meter ground-based Keck Telescopes by issuing proposal solicitations, conducting peer reviews, communicating selections for investigations, and providing support to observers. KSA also manages the Keck archives for the High Resolution Echelle Spectrometer (HIRES), and the Near Infrared Spectrometer (NIRSPEC) instruments. The HIRES primarily measures the radial velocity data used to find and characterize exoplanets and NIRSPEC is a general-purpose near-infrared spectrometer widely used by Keck observers.

DIRECTORATE SUPPORT

Space Science Project provides for critical safety and mission product inspections and contract audit services from the Defense Contract Management Agency and Defense Contract Audit Agency, respectively, as well as providing for supplier assurance contract audits, assessments and surveillance by the NASA Contract Assurance Services Program.

EDUCATION AND PUBLIC OUTREACH

SMD's Education and Public Outreach project provides a return on the public's investment in NASA's scientific research by sharing the story, the science and the adventure of NASA's scientific explorations of our home planet, the solar system, and the universe beyond. Experts create stimulating and informative activities and experiences, which are then delivered effectively and efficiently to learners of many backgrounds via proven conduits.

ASTROPHYSICS SENIOR REVIEW

The funding requested will extend the life of currently operating missions. Every other year, Astrophysics conducts a Senior Review to do comparative evaluates of all operating missions (both Explorers and strategic missions) that have already successfully completed or are about to complete their prime mission operation phase. A ranking based on science output is key to determining which missions will continue to receive funding for extended operations. The next senior review will take place in April 2012.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

ASTROPHYSICS DATA ANALYSIS PROGRAM (ADP)

ADP solicits research that emphasizes the analysis of NASA space astrophysics data that are archived in the public domain at one of NASA's Astrophysics Data Centers. Recent years have seen a dramatic growth in both the size and scope of the archival astronomical data available to ADP researchers, including data from such major strategic missions as Spitzer and Kepler. These data are already bought and paid for. Every dollar invested in archival research using this data brings additional value to the Nation's investment in the NASA mission. The steady increase in the program budget in coming years is designed to ensure continued effective use of this scientific resource as data holdings continue to grow.

ASTROPHYSICS DATA CURATION AND ARCHIVAL RESEARCH (ADCAR)

The Astrophysics Data Centers constitute an ensemble of archives that receive processed data from individual missions and make them accessible to the scientific community. After the completion of a mission, the relevant active multi-mission archive takes over all data archiving activities. ADCAR covers the activities of the Astrophysics Data Centers, and NASA's participation in the Virtual Astronomical Observatory. Priorities from the FY 2011 Archival Senior Review are being implemented in FY 2012 and beyond. For example, the NASA Exoplanet Archive will provide value-added science to the Kepler mission by disseminating the Kepler data, and serve as a clearinghouse for the follow-up ground-based observations required to confirm the nature of the Kepler exoplanet candidates.

COSMIC ORIGINS

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	**229.1**	**237.3**	**240.4**	**228.5**	**215.1**	**205.3**	**205.7**
Hubble Space Telescope	91.7	95.7	**98.3**	98.3	94.3	90.2	90.5
Stratospheric Observatory for Infrared Astronomy (SOFIA)	79.9	84.2	**85.5**	88.0	88.0	86.0	85.9
Other Missions and Data Analysis	57.6	57.4	**56.6**	42.2	32.8	29.1	29.3
Change From FY 2012 Estimate	--	--	**3.1**				
Percent Change From FY 2012 Estimate	--	--	**1.3%**				

This Hubble Space Telescope image shows one of the most massive young star clusters in the Milky Way Galaxy surrounded by a vast region of dust and gas. About 20,000 light years away and spanning roughly 17 light-years, this image reveals stages in the life cycle of stars.

The Cosmic Origins program investigates the evolution of the universe and its components, from the cosmic Big Bang to the present. Topics in Cosmic Origins research include: When did the first stars and galaxies form? How are stars and planets created? When did the universe first create elements critical for life? How do galaxies, stars, and planets change with cosmic time? Missions within Cosmic Origins have and continue to make important advances in finding answers to these questions.

Celebrating more than 20 years of operation, the Hubble Space Telescope (Hubble) continues to inspire through its exploration of the universe. Hubble images have enabled important discoveries on diverse topics, such as the violent and ever-evolving state of the solar system, new asteroid collisions, and the universe-wide "warming" that occurred 11 billion years ago when fierce blasts of radiation from voracious black holes stunted the growth of some small galaxies for a stretch of 500 million years. Through its annual call for observing proposals and online data archive, Hubble will serve thousands of astronomers with data over the full scope of Cosmic Origins questions.

The Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne telescope has completed its early science flights and promises to enable optical through far-infrared astronomy for decades. SOFIA is uniquely capable of studying the chemistry of the universe. It will help scientists study the chemical processes in star forming regions within this galaxy. SOFIA's far-infrared instruments will also study

distant galaxies. SOFIA will allow instrument upgrades through the coming years to leverage new technologies and reach new science goals.

Other Missions and Data Analysis supports NASA's partnership with ESA on Herschel, the newest operating Cosmic Origins telescope, which has made a critical finding about how water is formed in space. Analysis of Herschel data has revealed that ultraviolet starlight is the key ingredient for making water in space. Many more discoveries are expected over the next three years until Herschel's helium cryostat is depleted.

For more information, see http://nasascience.nasa.gov/about-us/smd-programs/cosmicorigins.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

No programmatic changes have been made.

BUDGET EXPLANATION

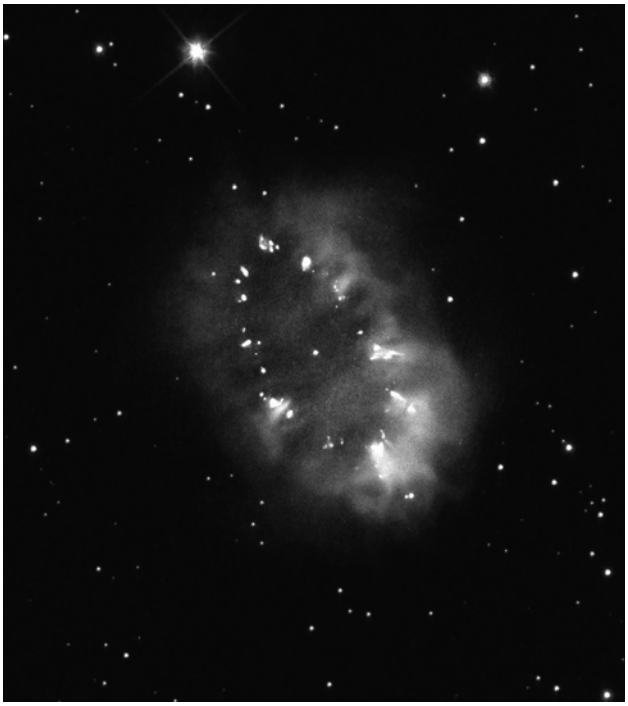
The FY 2013 request is $240.4 million. This represents a $3.1 million increase from the FY 2012 estimate ($237.3 million). The budget provides additional funding to support more robust technology development Cosmic Origins Strategic Research and Technology (SR&T) activities, as well as additional science funding for the Hubble Space Telescope.

HUBBLE SPACE TELESCOPE

Formulation	Development	Operations

FY 2013 BUDGET

Budget Authority (in $ millions)	Prior	Actual FY 2011	Estimate FY 2012	FY 2013	Notional FY 2014	FY 2015	FY 2016	FY 2017
FY 2013 President's Budget Request	**0.0**	**91.7**	**95.7**	**98.3**	**98.3**	**94.3**	**90.2**	**90.5**
Change From FY 2012 Estimate		--	--	**2.6**				
Percent Change From FY 2012 Estimate		--	--	**2.8%**				



This Hubble Space Telescope image shows the aptly named Necklace Nebula, a recently discovered planetary nebula, containing the glowing remains of an ordinary, Sun-like star.

One of NASA's most successful and long-lasting science missions, the Hubble Space Telescope has beamed hundreds of thousands of images back to Earth, shedding light on many of the great mysteries of astronomy. Its gaze has helped scientists determine the age of the universe, the identity of quasars, and the existence of dark energy. Hubble launched in 1990 and is currently in an extended operations phase. The fourth servicing mission, completed in 2009, added new batteries, gyros and instruments to extend its life even further into the future. The Cosmic Origins program is developing the capability to safely de-orbit Hubble after its mission has concluded is underway within the Cosmic Origins program. The timing for this activity will be determined by the status of the observatory and the orbital conditions that would drive an uncontrolled reentry.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

No programmatic changes have been made.

HUBBLE SPACE TELESCOPE

Formulation	Development	Operations

ACHIEVEMENTS IN FY 2011

In FY 2011, after 21 years of mission operations, the Hubble Mission Operations Center staffing transitioned from round-the-clock to single-shift/weekday-only, significantly decreasing the cost of operating the spacecraft. This was the culmination of a two-year effort to develop the automated systems and procedures required to minimize science data losses while ensuring that the health and safety of the spacecraft would not be compromised.

On July 4, 2011, Hubble conducted its one-millionth science observation, a spectroscopic measurement of the planet HAT-P-7b, a gas giant planet larger than Jupiter orbiting a star hotter than our sun.

Astronomers using the Hubble Space Telescope and the Chandra X-ray Observatory have found the first direct evidence that massive black holes are actively growing in the centers of the most distant galaxies known (galaxies forming within 950 million years of the Big Bang). Astronomers have long known that most galaxies in the present-day universe, including the Milky Way, harbor massive black holes at their hearts, but the origin of these black holes has long remained a mystery. They also predicted that a population of young black holes existed in the early universe, but had not observed them until now. Data obtained by Hubble and Chandra suggest that the baby black holes found in the early universe will eventually grow to become like the giant black holes seen in the current universe. Further, Hubble reached the unique milestone, as 10,000 refereed papers have been published using Hubble data. That makes Hubble one of the most prolific astronomical endeavors in history.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013 and beyond, NASA will support mission operations, systems engineering, software maintenance, ground systems support, and guest observer science grants. Hubble Cycle 21 observations will be selected. Based on Cycle 19, in which requested observational orbits outnumbered the available orbits by a factor of nine to one, this should be another highly selective process.

For Cycle 20 and beyond, data from all large and treasury programs will normally be shared immediately with the entire scientific community. Large and treasury programs are special classes of investigations that allow the kinds of discoveries only possible using large quantities of data, often taken over multiple years. Direct research grants comprise 25 to 30 percent of the Hubble budget, allowing scientists across the country to maximize the scientific value of the data collected by the telescope. Additional science funding will be dependent on the outcome of the Senior Review process in 2012.

BUDGET EXPLANATION

The FY 2013 request is $98.3 million. This represents a $2.6 million increase from the FY 2012 estimate ($95.7 million) and provides additional funds to ensure robust science selections.

HUBBLE SPACE TELESCOPE

Formulation	Development	Operations

Project Management & Commitments

Project/ Element	Provider	Description
Observatory operations	Provider: Lockheed Martin Project Management: GSFC NASA Center: GSFC Cost Share: None	Responsibilities include safe and efficient control and utilization of Hubble, maintenance and operation of its facilities and equipment, as well as creation, maintenance, and utilization of Hubble operations processes and procedures
Science management	Provider: STScI Project Management: GSFC NASA Center: GSFC Cost Share: ESA	Evaluate proposals for telescope time and manage the science program

Acquisition Strategy

All new grant and research selections are made competitively.

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Observatory operations	Lockheed Martin	Littleton, CO
Science management	Space Telescope Science Institute	Baltimore, MD

HUBBLE SPACE TELESCOPE

Formulation	Development	Operations

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Senior Review	N/A	Determine is mission operations should be extended, and if approved extend science operations.	2012, 2014, 2016

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

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	**812.4**	**79.9**	**84.2**	**85.5**	**88.0**	**88.0**	**86.0**	**85.9**	**1,593.1**	**3,002.9**
2012 MPAR Project Cost Estimate	**812.4**	**79.9**	**84.2**	**85.5**	**88.0**	**88.0**	**86.0**	**85.9**	**1,593.1**	**3,002.9**
Formulation	35.0	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	35.0
Development/ Implementation	777.4	79.9	84.2	**85.5**	88.0	13.5	0.0	0.0	0.0	1,128.5
Operations/close-out	0.0	0.0	0.0	**0.0**	0.0	74.5	86.0	85.9	1,593.1	1,839.5
Change From FY 2012 Estimate		--	--	**1.3**						
Percent Change From FY 2012 Estimate		--	--	**1.5%**						

NASA is developing SOFIA as a world-class airborne observatory that will complement the Hubble, Spitzer, Herschel and the James Webb Space Telescope. SOFIA's ability to return to earth after each flight also makes it an outstanding laboratory for developing and testing new astronomical instrumentation and detector technology throughout its lifetime.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

There have been no schedule or scope changes.

PROJECT PURPOSE

SOFIA is a unique airborne astronomical observatory, whose primary mission is to study many different kinds of astronomical objects and phenomena. SOFIA will investigate star birth and death and the formation of new solar systems; it will identify complex molecules in space; and it will observe planets, comets and asteroids in our solar system, as well as nebulae and dust in galaxies. The infrared light of these objects is only partially visible from the ground due to water vapor in the Earth's atmosphere. However, at high altitudes, the influence of water vapor is negligible, allowing better observation of these astronomical objects.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

During its 20-year expected lifetime, SOFIA will be capable of enabling "Great Observatory" class astronomical science. SOFIA will soon be NASA's only far-infrared mission, as Spitzer cryogens have been depleted and Herschel's cryogens will be exhausted by 2013. It is the only mid-infrared mission until JWST becomes operational. SOFIA's reconfigurability and flexibility ensures the integration of cutting edge technology and the ability to address emerging scientific questions.

PROJECT PARAMETERS

SOFIA is designed as a highly modified Boeing 747SP aircraft with a large open-port cavity aft of the wings, housing a 2.5 meter telescope optimized for infrared/sub-millimeter wavelength astronomy. SOFIA will operate in flight at 41,000 feet, and at full operational capability (FOC) will have four instruments, with additional instruments available after full operational capability. SOFIA will ramp up to 960 science hours per year.

ACHIEVEMENTS IN FY 2011

SOFIA completed its early science campaign, consisting of 29 science flights. Early Science employed the Faint Object InfraRed CAmera for the SOFIA Telescope (FORCAST) and the German Receiver for Astronomy at Terahertz Frequencies (GREAT). This work was accomplished in parallel with continued development of the Observatory.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

SOFIA will complete Cycle 1 science observations, or the first full set of observing campaigns with general observers. Further, the SOFIA program will complete the Systems Requirements Review for the initial second generation SOFIA instrument.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

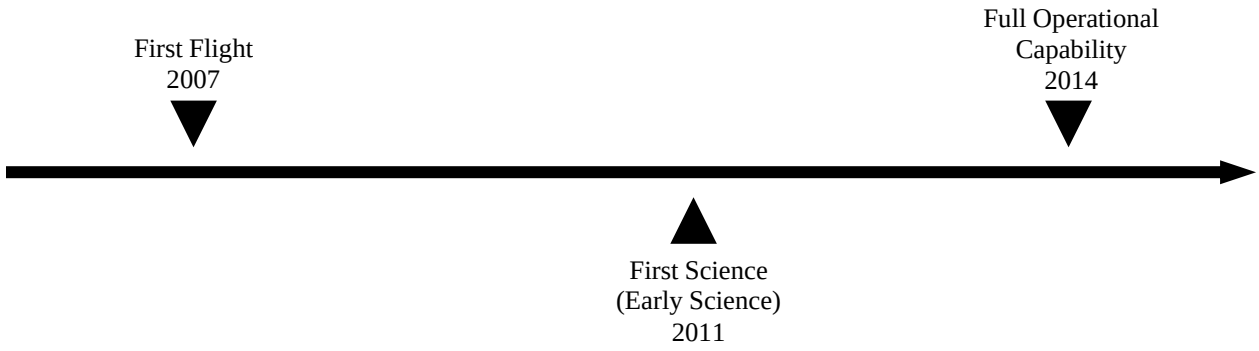
Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

SOFIA began Early Science flights in 2011 and will be in full operational capability by December 2014.

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
First Flight	2000	2007
First science (Early Science)	N/A	2011
Full operational capability	N/A	2014
End of Prime Mission	N/A	2034

Project Schedule



STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

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)
2007	919.5	70	2012	1,128.40	23	FOC	Dec-13	Dec-14	12

Note: *The confidence level estimates reported reflect an evolving process as NASA improves its probabilistic estimation techniques and processes. Estimate reflects the practices and policies at the time it was developed. Estimates that include combined cost and schedule risks are denoted as JCL (Joint Confidence Level); all other CLs (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:	**919.5**	**1128.4**	**208.9**
Aircraft/Spacecraft	657.7	768.4	110.7
Science/Technology	199.6	225.7	26.1
Other Direct Project Costs	62.2	134.3	72.1

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

Project Management & Commitments

The overall SOFIA project and SOFIA airborne system are managed by DFRC. SOFIA science is managed by ARC.

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Platform	Provider: DFRC/L3 Project Management: DFRC NASA Center: DFRC Cost Share: DLR/DSI	Refurbished Boeing 747SP modified to accommodate telescope	Same	Same
Science Operations Center	Provider: ARC/USRA Project Management: ARC NASA Center: ARC Cost Share: DLR/DSI	Science operations center will schedule observations, and manage data acquisition and processing	Same	Same
Telescope	Provider: Germany-DLR/DSI Project Management: DFRC NASA Center: DFRC Cost Share: DLR/DSI	2.5 meter diameter, dual mirror	Same	Same
Flight Operations	Provider: DFRC/CSC DynCorp Project Management: DFRC NASA Center: DFRC Cost Share: DLR/DSI	Flight crew, maintenance, and fuel	Same	Same

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

Project/ Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
High-speed Photometer for Occulations (HIPO)	Provider: Lowell Observatory Project Management: ARC NASA Center: ARC Cost Share: N/A	Simultaneous high-speed time-resolved imaging photometry at two optical wavelengths	Same	Same
First Light Infrared Test Experiment Camera (FLITECAM)	Provider: UCLA Project Management: ARC NASA Center: ARC Cost Share: N/A	Large field-of-view, narrow- and broad-band photometric imaging and low-resolution spectroscopy from 1 to 5.5 micrometers	Same	Same
FORCAST	Provider: Cornell University Project Management: ARC NASA Center: ARC Cost Share: N/A	Large field-of-view, narrow- and broad-band photometric imaging and moderate-resolution spectroscopy from 4 to 42 micrometers	Same	Same
Echelon-Cross - Echelle Spectrograph (EXES)	Provider: ARC Project Management: ARC NASA Center: ARC Cost Share: N/A	Echelon spectrometer, 5-28 microns R=105, 104, or 3000	Same	Same
High-resolution Airborne Wideband Camera (HAWC)	Provider: University of Chicago Project Management: ARC NASA Center: ARC Cost Share: N/A	Far-infrared bolometer camera, 50-240 microns	Same	Same

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
German Receiver for Astronomy at Terahertz Frequencies (GREAT)	Provider: Germany-DLR/DSI Project Management: ARC NASA Center: ARC Cost Share: DLR/DSI	IR heterodyne spectrometer 60 to 200 microns	Same	Same
Field Imaging Far-Infrared Line Spectrometer (FIFI LS)	Provider: Germany-DLR/DSI Project Management: ARC NASA Center: ARC Cost Share: DLR/DSI	Imaging spectrometer 42 to 210 microns	Same	Same

Project Risks

Risk Statement	Mitigation
If: Telescope image quality goals cannot be met, Then: Some planned science observations will not be possible.	Appointed the joint U.S.- German SOFIA Pointing Optimization Team to study telescope pointing performance and make recommendations for improvements. Installed active mass dampers on telescope to reduce image jitter.
If: Primary mirror is damaged due to handling mishaps, Then: Observatory will be inoperable during mirror repair and/or replacement.	Have contract in place to move Mirror Coating Facility from SOFIA Science Center (Moffett Field, CA) to Aircraft Operations Facility (Palmdale, CA). This will allow coating to take place at home base of Observatory. Also have developed snow cleaning techniques to preserve telescope optical characteristics as long as possible without recoating. Implementing a contamination control program.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Platform	L3 Communications	Waco, TX
Cavity Door Drive System	MPC Products Corporation	Skokie, IL
Aircraft Maintenance Support	CSC DynCorp	El Segundo, CA
Science Operations	University Space Research Association	Columbia, MD

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	Assess progress toward establishing Full Operational Capability milestone.	Nov-12
Performance	SRB	N/A	Evaluate observatory performance against Level 1 requirements and 2nd-generation instrument interfaces. Review overall operational efficiency of Observatory.	Nov-14
Performance	SRB	Nov-14	Evaluate Observatory performance against Level 1 requirements and instrument interfaces. Review overall operational efficiency of Observatory.	Nov-16

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

CORRECTIVE ACTION PLAN AS REQUIRED BY SECTION 1203 OF NASA 2010 AUTHORIZATION ACT

SOFIA is an airborne observatory that will study the universe in the infrared spectrum. These infrared observations allow scientists to study the dust between stars, the formation of stars and new solar systems, the chemistry of the universe, and the deep universe where the most distance galaxies are seen in infrared light. SOFIA will host a complement of scientists, computer engineers, graduate students, and educators on nightlong research missions. SOFIA will be a major factor in the development of observational techniques and of new instrumentation and in the education of young scientists and teachers in the discipline of infrared astronomy.

NASA and DLR, Germany's Aerospace Research Center and Space Agency, are working together to construct SOFIA, a Boeing 747SP aircraft which was modified by L3 Communications Integrated Systems to accommodate a 2.5 meter reflecting telescope. SOFIA will be the largest airborne observatory in the world and will make observations that are impossible for even the largest and highest of ground-based telescopes. SOFIA will operate at 41,000 feet using U.S. and German instruments and flights will last, on average, six to eight hours.

STRATOSPHERIC OBSERVATORY FOR INFRARED ASTRONOMY (SOFIA)

Formulation	Development	Operations

2010 Issues	Corrective Action Plan
Issue 1: Definition of Full Operational Capability Milestone Requirements Current Status: The Full Operational Capability milestone requirements have been revised to emphasize science instrument observational capability (4 science instruments), the overall program has been replanned in terms of schedule (no change in Full Operational Capability date, however), and the NASA Agency Program Management Council has approved the replan.	Programmatic: Programmatic – Review of the definition of the Full Operational Capability milestone technical requirements by the independent Standing Review Board (SRB) resulted in a finding by the SRB that the original definition (800 flight hours per year) was an improper definition in that insufficient science emphasis was contained in the definition. Therefore, the definition of Full Operational Capability was revised to focus on science instrument capability (the requirement was revised to four available science instruments, consistent with the MPAR definition), and the overall program was replanned around that definition. The replanned program plan was approved by the NASA Agency Program Management Council (APMC) on October 6, 2010. This did not cause a change in the externally-committed FOC date of December 2014, but does emphasize science in the definition.
Issue 2: Late delivery of Cavity Door Drive System Current Status: The cavity door drive system controller and actuator was delivered and integrated in the SOFIA observatory, and flight testing to clear the full flight envelope has been completed. This permits the continuation of SOFIA system testing, leading up to the first science flights in December 2010.	Programmatic: Late delivery of software that operates the telescope observation doors on the aircraft resulted in later-than-planned initiation of open door flight testing and science observation. NASA stationed representatives at Woodward's facility to support and oversee the vendor until delivery of the cavity controller and actuator.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

FY 2013 BUDGET

	Actual	Estimate		Notional			
Budget Authority (in $ millions)	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**57.6**	**57.4**	**56.6**	**42.2**	**32.8**	**29.1**	**29.3**
Cosmic Origins Program Management	1.7	4.0	**4.9**	5.2	5.3	5.4	5.5
Cosmic Origins SR&T	7.9	10.6	**19.4**	19.5	20.7	21.7	21.8
Cosmic Origins Future Missions	0.7	1.0	**1.7**	1.7	1.0	2.0	2.0
Spitzer	22.7	17.8	**9.8**	0.0	0.0	0.0	0.0
Herschel	24.6	24.0	**20.8**	15.8	5.8	0.0	0.0
Change From FY 2012 Estimate	--	--	**-0.8**				
Percent Change From FY 2012 Estimate	--	--	**-1.4%**				

To understand how the universe has changed from its initial simple state following the Big Bang into the magnificent universe seen in the current night sky, NASA must understand how stars, galaxies and planets are formed over time. Activities within Cosmic Origins are aimed at enabling research into the big question: "How did the universe originate and evolve to produce the galaxies, stars, and planets we see today?"

Non-Operating Missions

COSMIC ORIGINS PROGRAM MANAGEMENT

Cosmic Origins program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

COSMIC ORIGINS STRATEGIC RESEARCH AND TECHNOLOGY (SR&T)

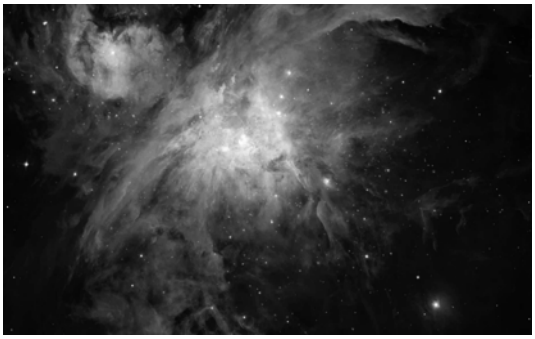
Cosmic Origins SR&T supports Hubble fellowships, program-specific research and advanced technology development efforts such as the Strategic Astrophysics Technology solicitation issued in FY 2011, and detectors for NASA's contribution to a partnership with ESA on the Euclid mission. Three investigations were selected under this solicitation to advance the technology readiness level in the areas of UV detectors, optical coatings, and large optical components. In addition, funding supports the study of a future UV-optical space capability, wide-field infrared imaging and spectroscopy, particularly in the area of advanced detector technology, and Hubble de-orbit planning.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

COSMIC ORIGINS FUTURE MISSIONS

The Cosmic Origins Future Missions element funds concept studies for future missions in accordance with the NASA strategic plan.



This is a false-color composite image of the Orion Nebula created from Spitzer and Hubble Space Telescope data. It exposes the chaos that baby stars are creating 1,500 light-years away. The cosmic cloud is also our closest massive star-formation factory, and astronomers believe it contains more than 1,000 young stars.

Operating Missions

SPITZER SPACE TELESCOPE

The Spitzer Space Telescope launched in 2003 and is now in extended operations. Spitzer is an infrared telescope using two channels of the Infrared Array Camera instrument to study the atmosphere of exoplanets, looking for the earliest clusters of galaxies, near Earth asteroids and providing a 360 degree map of the galaxy. Spitzer completed its cryogenic mission in FY 2009, and warm operations have been extended through FY 2013. The outcome of the 2012 Senior Review will authorize beyond 2013, if appropriate.

HERSCHEL SPACE OBSERVATORY

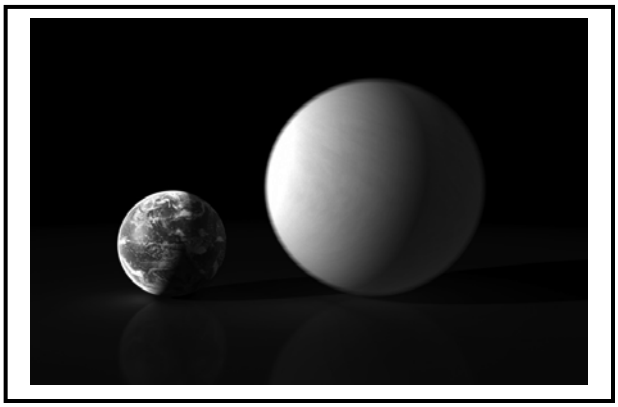
The Herschel Space Observatory is a collaborative mission with ESA which launched on May 14, 2009. Herschel can see the coldest and dustiest objects in space, for example, cool cocoons where stars form and dusty galaxies bulk up with new stars. It has the largest single mirror ever built for a space telescope and it will collect long wavelength radiation from some of the coldest and most distant objects in the universe. NASA has contributed key technologies to two instruments onboard Herschel, and also hosts U.S. astronomer access to data through the NASA Herschel Science Center.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

Recent Achievements

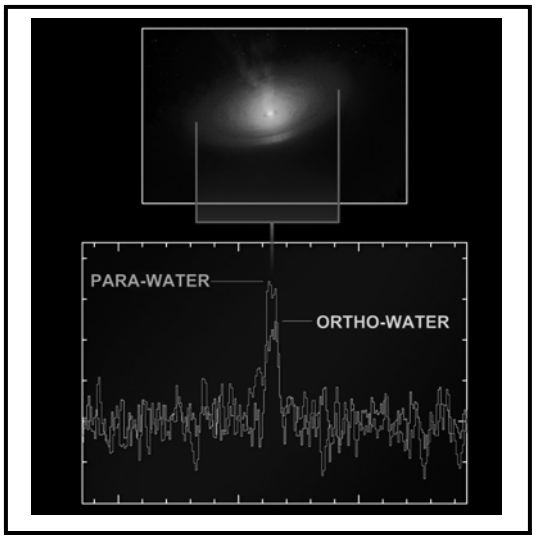
SPITZER DISCOVERS "SUPER-EARTH"



NASA's Spitzer Space Telescope has gathered surprising new details about a supersized and superheated world referred to as 55 Cancri e. Astronomers first discovered 55 Cancri e in 2004, and continued investigation of the exoplanet has shown it to be a truly unusual place. The world revolves around its sun-like star in the shortest time period of all known exoplanets just 17 hours and 40 minutes. In other words, a year on 55 Cancri e lasts less than 18 hours.

The new observations from Spitzer reveal 55 Cancri e to have a mass 7.8 times and a radius just over twice that of Earth. Those properties place 55 Cancri e in the "super-Earth" class of exoplanets, a few dozen of which have been found. However, what makes this world so remarkable is its low density. The Spitzer results suggest that about a fifth of the planet's mass must be made of light elements and compounds, including water. In the intense heat of 55 Cancri e's close sun, those light materials would exist in a "supercritical" state, between that of a liquid and a gas, and might sizzle out of the planet's surface.

At just 40 light years away, 55 Cancri e stands as the smallest transiting super-Earth in our stellar neighborhood. In fact, 55 Cancri is so bright and close that it can be seen with the naked eye on a clear, dark night. Please read about Spitzer's other achievements at http://www.spitzer.caltech.edu/.



COLD WATER VAPOR SEEN BY HERSCHEL

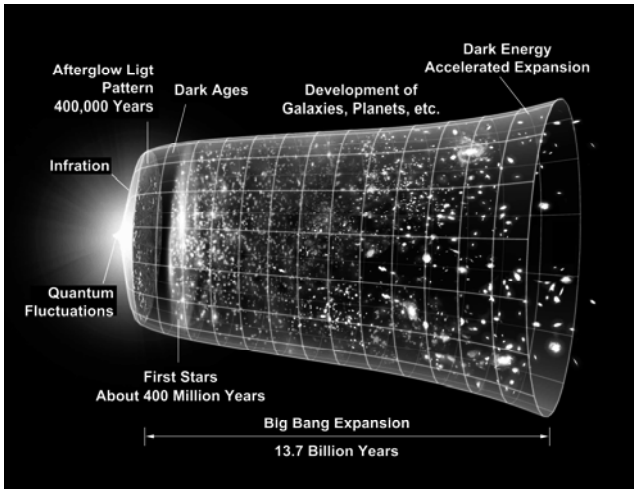
Using the Herschel Space Observatory, astronomers have for the first time detected cold water vapor in a protoplanetary disk. Located in a thin layer at intermediate depths in the disc, the cold vapor hints at a much larger reservoir of water ice hidden deeper in the disc and amounting to several thousand times the mass of water that makes up our planet's oceans. The discovery sheds new light on the presence and role of water in the early formation stages of a planetary system.

Read about Herschel's achievements at http://sci.esa.int/science-e/www/area/index.cfm?fareaid=16.

PHYSICS OF THE COSMOS (PCOS)

FY 2013 BUDGET

	Actual	Estimate		Notional			
Budget Authority (in $ millions)	**FY 2011**	**FY 2012**	**FY 2013**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**
FY 2013 President's Budget Request	**108.7**	**108.3**	**111.8**	**109.6**	**96.3**	**92.7**	**74.6**
Change From FY 2012 Estimate	--	--	**3.5**				
Percent Change From FY 2012 Estimate	--	--	**3.2%**				



This diagram reveals changes in the rate of expansion since the universe's birth 15 billion years ago. The discovery that the expansion of space is accelerating presents one of the most important scientific problems of our time. The implication that the universe is dominated by an unknown entity, now called "dark energy," that counters the attractive force of gravity, may revolutionize our understanding of cosmology and fundamental physics.

The universe can be viewed as a laboratory that enables scientists to study some of the most profound questions at the intersection of physics and astronomy. How did the universe begin? How do matter, energy, space, and time behave under the extraordinarily diverse conditions of the cosmos? The Physics of the Cosmos (PCOS) program incorporates cosmology, high-energy astrophysics, and fundamental physics projects that address central questions about the nature of complex astrophysical phenomena such as black holes, neutron stars, dark matter and dark energy, Cosmic microwave background, and gravitational waves.

The operating missions within the PCOS program are just beginning to provide answers to the fundamental questions above. Scientists using data from the Fermi mission are trying to determine what composes mysterious dark matter, which will help explain how black holes accelerate immense jets of material to nearly the speed of light. Planck is observing the earliest moments of the universe and is providing a high-resolution map of the cosmic microwave background. X-Ray Multi-Mirror Mission (XMM)-Newton has helped scientists solve cosmic mysteries, ranging from enigmatic black holes to the origins of the universe itself. Chandra continues to reveal new details of celestial x-ray phenomena, such as the collisions of galaxies that directly detect the presence of dark matter, and has unveiled a population of faint, obscured massive black holes that may provide the early seeds for galaxy formation and growth.

PCOS includes a vigorous program of development of technology to detect the imprint of gravitational waves on the cosmic microwave background produced during the first few moments of the universe, and to detect the waves produced by the mergers of massive black holes in galaxies.

For more information, see http://nasascience.nasa.gov/about-us/smd-programs/physics-of-the-cosmos.

PHYSICS OF THE COSMOS (PCOS)

EXPLANATION OF MAJOR CHANGES FOR FY 2013

NASA and ESA are re-evaluating their mission priorities and available funding in Astrophysics for the next decade. The NASA/ESA partnership on formulation activities for a gravitational wave mission, the Laser Interferometer Space Antenna, (LISA), and an advanced x-ray telescope, the International X-ray Observatory or IXO have been discontinued.

ACHIEVEMENTS IN FY 2011

In FY 2011, scientists using NASA's Fermi Gamma-ray Space Telescope detected beams of antimatter produced above thunderstorms on Earth, a phenomenon never seen before. The scientists found that these antimatter particles, called positrons, were the result of a terrestrial gamma-ray flash, a brief burst produced inside thunderstorms known to be associated with lightning. They estimate that about 500 terrestrial gamma-ray flashes occur around the world daily, but most go undetected. The data collected by Fermi was the first direct evidence that thunderstorms make antimatter particle beams.

The PCOS Program Analysis Group appointed its Executive Committee. This group serves as a forum for soliciting and coordinating input and analysis from the scientific community in support of PCOS program objectives. The PCOS program also released the inaugural Program Annual Technology Report. This report summarizes the status of technology development funded by the program in FY 2011 and describes the prioritization of future technology needs.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

In FY 2013, NASA will continue to develop strategic PCOS technologies. NASA plans to solicit technologies in x-ray astrophysics, gravitational wave astrophysics, cosmic microwave background polarization measurements, and fundamental physics.

BUDGET EXPLANATION

The FY 2013 request is $111.8 million. This represents a $3.5 million increase from the FY 2012 estimate ($108.3 million) and provides additional funds to augment technology development activities and to ensure a robust Fermi science program.

PHYSICS OF THE COSMOS (PCOS)

Non-Operating Missions

PCOS SUPPORTING RESEARCH AND TECHNOLOGY

PCOS Supporting Research and Technology supports Einstein Fellowships and program-specific research and early technology development efforts such as x-ray and gravitational wave detectors. The Space Technology (ST)-7 project to fly on the ESA LISA Pathfinder mission is supported within this budget and is now scheduled for launch in 2014. NASA is developing a disturbance reduction system with enhanced thruster technology, which will work with enhanced sensor technology provided by ESA. Together, these technologies will demonstrate precision positioning of the spacecraft to ensure that the planned gravitational experiment is conducted in a truly weightless environment. The ST-7 thrusters will be able to achieve millimeter positioning of the spacecraft by applying thrust equivalent to the weight of a single grain of sand.

In FY 2011, the program began developing core technology investment strategy. It is anticipated that activities in 2012 and 2013 will focus on the development of x-ray and gravity wave detection technologies.

PCOS PROGRAM MANAGEMENT

PCOS program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

PCOS FUTURE MISSIONS

PCOS Future Missions funding supports future mission concept studies.

Operating Missions

PLANCK

Planck, launched in May 2009, is an ESA-led mission with substantial NASA contributions. Planck is peering back to the edge of the universe to observe the earliest moments of creation, using the coldest instruments in space. Planck's objective is to analyze, with the highest accuracy ever achieved, the remnants of the radiation that filled the universe immediately after the Big Bang and that we observe today as the Cosmic Microwave Background. Planck enables scientists to help elucidate a number of fundamental questions, such as the initial conditions for the evolution in the universe, the overall geometry of space, the rate at which the universe is expanding, and the nature and amount of the constituents of the universe.

PHYSICS OF THE COSMOS (PCOS)

In FY 2011, Planck completed most of its fourth sky survey with instruments and spacecraft performing well. In 2012 the dilution cooler phase of the mission will conclude. Project management will propose an extended, “warm” mission in the 2012 Senior Review. Operations in 2013 will depend on the results of that review.

FERMI

The Fermi Gamma-ray Space Telescope is a joint NASA/DoE mission with strong international involvement. Fermi was launched in June 2008 and is currently in its prime operational phase. Fermi’s two instruments, the Large Area Telescope and the Gamma-ray Burst Monitor, have discovered hundreds of gamma ray bursts, expanding our knowledge of their high-energy properties. Fermi has uncovered a new class of pulsars, seen only at gamma-rays energies. Fermi has monitored more than a thousand galaxies whose supermassive black holes generate high-speed jets of material directed toward the Earth from across the universe. Fermi data are also providing new insight into the origin of cosmic rays.
In FY 2011 Fermi continued prime mission operations. In 2013, Fermi will continue operations and program managers will select another cohort of guest investigators.

CHANDRA

Chandra is transforming our view of the universe with its high quality x-ray images, providing unique insights into violent events and extreme conditions such as explosions of stars, collisions of galaxies, and matter around black holes. The contributions of Chandra to astrophysics are numerous. Among the most notable are its observations of the Bullet Cluster of Galaxies that provided direct evidence for the existence of dark matter. In addition, studies of clusters of galaxies using Chandra data have greatly strengthened the case for the existence of dark energy. Chandra observations of the remains of exploded stars, or supernovas, have advanced our understanding of the behavior of matter and energy under extreme conditions. In addition, Chandra has discovered and studied of hundreds of supermassive black holes in the centers of distant galaxies.

In FY 2011, Chandra continued in its extended mission phase. Continued operations beyond FY 2012 are dependent upon the results of the 2012 Senior Review.

XMM-NEWTON

XMM-Newton launched in December 1999, is an ESA-led mission with substantial NASA contributions. XMM-Newton provides unique data for studies of the fundamental processes of black holes and neutron stars. It also studies the evolution of chemical elements in galaxy clusters and the distribution of dark matter in galaxy clusters and elliptical galaxies. NASA provides the NASA Guest Observer Facility at GSFC.

In FY 2011, XMM-Newton continued extended operations. The results of the 2012 Senior Review will determine further operations in 2013 are dependent on the results of the 2012 Senior Review.

PHYSICS OF THE COSMOS (PCOS)

Program Management & Commitments

PCOS program management is the responsibility of GSFC.

Project/Element	Provider
Fermi	Provider: SpectrumAstro, now Orbital Project Management: GSFC NASA Center: GSFC Cost Share: DOE, Japan, Italy, France, Sweden, Germany
Planck	Provider: ESA Project Management: JPL NASA Center: JPL Cost Share: ESA
Chandra	Provider: TRW, now Northrup Grumman Project Management: MSFC NASA Center: MSFC Cost Share: None
XMM	Provider: ESA Project Management: GSFC NASA Center: GSFC Cost Share: ESA
ST-7	Provider: JPL Project Management: JPL NASA Center: JPL Cost Share: ESA

Acquisition Strategy

Technology awards will be made in response to annual NRAs released in ROSES-2012.

PHYSICS OF THE COSMOS (PCOS)

INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	2011	Review the implementation plans for the PCOS program	2013
Quality	Senior Review	2010	Determine which mission operations should be extended	2012, 2014

EXOPLANET EXPLORATION

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	**46.4**	**50.8**	**56.0**	**41.6**	**43.3**	**42.4**	**45.6**
Kepler	16.8	19.6	**13.6**	0.2	0.0	0.0	0.0
Keck Operations	3.6	3.2	**3.3**	3.4	3.5	3.5	3.5
Exoplanet Exploration SR&T	14.9	18.1	**28.0**	28.2	30.8	31.1	34.3
Large Binocular Telescope Interferometer	1.5	2.0	**3.8**	2.9	2.0	0.5	0.5
Exoplanet Exploration Program Management	4.8	6.0	**6.1**	5.7	5.9	6.0	6.0
Exoplanet Exploration Future Missions	1.2	1.5	**1.2**	1.2	1.2	1.2	1.2
Wide Field Infrared Space Telescope	3.6	0.0	**0.0**	0.0	0.0	0.0	0.0
Keck Interferometer	0.1	0.4	**0.0**	0.0	0.0	0.0	0.0
Change From FY 2012 Estimate	--	--	**5.2**				
Percent Change From FY 2012 Estimate	--	--	**10.3%**				

This artist's conception shows a planet orbiting its parent star. The Kepler mission will observe thousands of such stars in its search for Earth-like planets. Results from this mission will allow us to place our solar system within the continuum of planetary systems in the Galaxy.

Humankind stands on the threshold of a voyage of unprecedented scope and ambition, promising insight into some of the most timeless questions: Are we alone? Is Earth unique, or are planets like ours common? One of the most exciting new fields of research within the NASA Astrophysics portfolio is the search for planets, particularly Earth-like planets, around other stars.

During the last 15 years, astronomers have discovered over 500 planets orbiting nearby stars. Most of these planets are gas giants, similar in size to the four outer planets in this solar system, and orbit much closer to their parent stars than do the giant planets in this system. NASA's Exoplanet Exploration program is taking the first steps along a path of discovery that will lead to a point where scientists can directly study the atmospheres and surface features of habitable, rocky planets, like Earth, around other stars in the solar neighborhood.

To date, most of the known extrasolar planets, or simply exoplanets, have been discovered with ground-based telescopes. However, the 2009 launch of NASA's Kepler mission, NASA's first mission dedicated to the study of extrasolar planets, has ushered in a new chapter in the search for planets around other stars. From its unique vantage point of space, Kepler is capable of detecting much smaller planets than are

EXOPLANET EXPLORATION

possible with even the most powerful ground based telescopes. Kepler has already provided data that has shown us that small planets are more abundant than giant planets. Within two years of launch, Kepler will double the number of known exoplanets, including many rocky planets only a few times larger than Earth. By the end of its prime mission, Kepler will enable the first measurements of just how common habitable, Earth-sized planets are in the galaxy.

NASA's Exoplanet Exploration program creates images and spectroscopy of rocky planets in the habitable zones of stars in the solar neighborhood. These capabilities allow NASA to take the pivotal step from identifying an exoplanet as Earth-sized, to determining whether it is truly Earth-like, and possibly even if it bears the fingerprints of life. As such an ambitious goal includes significant technological challenges, an important component of the Exoplanet Exploration effort will be a robust technology development program focused on technologies that feed into the candidate architectures for a future direct detection mission.

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

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The budget provides additional funding for the Large Binocular Telescope Interferometer instrument to support more robust science, for example improved detection of emission from faint dust clouds. Funds originally intended for the Wide Field Infrared Survey Telescope technology development have been descoped.

ACHIEVEMENTS IN FY 2011

In February 2011, astronomers using Kepler found the first Earth-size planet candidates and the first candidates in the habitable zone, a region where liquid water could exist on a planet's surface and that could potentially host life. Kepler also found six confirmed planets orbiting a sunlike star. This is the largest group of transiting planets orbiting a single star ever discovered outside the solar system.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The Exoplanet Advisory Group has begun defining science requirements and the technical framework for concept studies on the next exoplanet exploration mission. Initial concept studies will begin in FY 2013 commensurate with available funds.

BUDGET EXPLANATION

The FY 2013 request is $56.0 million. This represents a $5.2 million increase from the FY 2012 estimate ($50.8 million) and provides additional funds to ensure robust technology development activities.

EXOPLANET EXPLORATION

Non-Operating Missions

EXOPLANET EXPLORATION PROGRAM MANAGEMENT

Exoplanet Exploration program management provides programmatic, technical, and business management, as well as program science leadership and coordination for education and public outreach products and services.

EXOPLANET EXPLORATION FUTURE MISSIONS

Exoplanet Exploration Future Missions funding will support the next EXEP mission once it is selected.

Operating Missions

KEPLER

Kepler, launched in March 2009, is specifically designed to survey the distant stars in this region of the Milky Way galaxy to detect and characterize rocky planets in or near the "habitable zone" of their host star. The habitable zone encompasses the distances from a star where liquid water can exist on a planet's surface. As time progresses, smaller and smaller planets with longer and longer orbital periods will begin to emerge from the data.

In FY 2011, Kepler completed its second year of science operations. Kepler observations have resulted in numerous scientific discoveries and the project has released a substantial data set to the astronomical community. The Kepler prime mission will be completed in November 2013. Future Kepler observations to further characterize planetary candidates will depend on the outcome of the 2012 Senior Review.

KECK OPERATIONS

Keck Operations is the NASA portion of the Keck Observatory partnership. NASA uses its share of observing time in support of all Astrophysics science programs. Observation time is competed, selected, and managed by the NASA Exoplanet Science Institute. A significant portion of the NASA Keck competed time has been awarded to Kepler follow-up observations on potential planet candidates and radio-velocity observations for new exoplanet discoveries.

EXOPLANET EXPLORATION

EXOPLANET EXPLORATION STRATEGIC RESEARCH AND TECHNOLOGY

Exoplanet Exploration Strategic Research and Technology supports the prestigious Sagan Postdoctoral Fellowships, program-specific scientific research, and technology development activities that support and enable future Exoplanet Exploration missions.

In FY 2011, NASA supported approximately 17 Sagan fellows, supported an exoplanet exploration program conference, and awarded over $3 million for competitively selected technology development activities. In 2013, NASA will continue to maintain the capabilities essential to carrying out technology development, such as testbeds and vacuum chambers, and partially fund procurement of detectors for NASA's contribution to a Euclid partnership with ESA. NASA will continue the competitive technology awards to work on internal coronagraphs, external occulters and visible nulling coronagraphs. At least 17 Sagan fellows will be supported.

LARGE BINOCULAR TELESCOPE INTERFEROMETER

The Large Binocular Telescope Inferometer (LBTI) is the NASA portion of the Large Binocular Telescope (LBT) partnership. The project is funded by NASA and managed by JPL. The instrument and project development are provided by the Steward Observatory of the University of Arizona. The instrument is currently under development, and will be ready for full science operations in FY 2012. LBTI will enable the study of the formation of solar systems and will be capable of directly detecting giant planets outside this solar system. LBTI will help scientists determine the amount of dust that is found in nearby planetary systems. This is an important factor to take into consideration for the development of a direct detection mission, one of the primary challenges for the next exoplanet mission. In FY 2011, development of the interferometer continued, and will be complete in 2012. In 2013, LBTI will conduct key science operations to characterize planetary systems orbiting other stars.

EXOPLANET EXPLORATION

Program Management & Commitments

JPL manages the Exoplanet Exploration Program.

Project Element	Provider
Kepler	Provider: JPL Project Management: ARC NASA Center: ARC Cost Share: None
Keck Observatory	Provider: Caltech and University of California Project Management: JPL NASA Center: None Cost Share: Various private entities
LBTI	Provider: University of Arizona Project Management: JPL NASA Center: None Cost Share: University of Arizona

Acquisition Strategy

NASA will make technology awards in response to annual NRAs released in ROSES-2012 solicitations.

MAJOR CONTRACTS/AWARDS

None

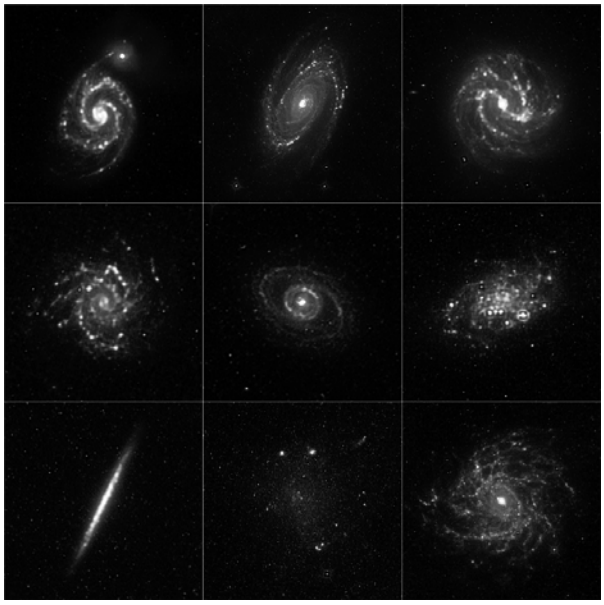
INDEPENDENT REVIEWS

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review	2010	Determine which mission operations should be extended	2012, 2014

ASTROPHYSICS EXPLORER

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	**100.0**	**112.2**	**75.1**	**134.3**	**133.9**	**157.0**	**165.6**
Nuclear Spectroscopic Telescope Array	36.1	11.8	**4.7**	4.4	0.0	0.0	0.0
Gravity and Extreme Magnetism	23.0	63.2	**46.4**	32.9	2.7	0.2	0.0
Other Missions and Data Analysis	41.0	37.2	**24.1**	97.1	131.2	156.8	165.6
Change From FY 2012 Estimate	--	--	**-37.1**				
Percent Change From FY 2012 Estimate	--	--	**-33.1%**				



A collection of galaxy specimens from the Wide-field Infrared Survey Explorer (WISE) mission showcases galaxies of several types.

The Astrophysics Explorer program provides frequent flight opportunities for world-class astrophysics and heliophysics investigations using innovative and streamlined management approaches for spacecraft development and operations. Explorer missions are highly responsive to new knowledge, new technology, and updated scientific priorities by launching smaller missions that can be conceived and executed in a relatively short development cycle. Priorities are based on an open competition of concepts solicited from the scientific community. The program emphasizes missions that can be accomplished under the control of the scientific research community within constrained mission life-cycle costs. The program also seeks to enhance public awareness of space science by incorporating educational and public outreach activities as integral parts of space science investigations.

The standard Explorer missions are investigations characterized by definition, development, and mission operations and data analysis costs up to $200 million, not including launch services. Small Explorers (SMEX) may cost up to $120 million, not including launch services. Explorer missions of opportunity (MO) have a total NASA cost of under $55 million and may be of several types. The most common are partner MOs, investigations characterized by being part of a non-NASA space mission. These missions are conducted on a no-exchange-of-funds basis with the organization sponsoring the mission. Other possible types are new science missions using existing spacecraft, and small complete missions. NASA intends to solicit proposals for missions of opportunity with each announcement of opportunity issued for Explorer and SMEX investigations, and perhaps more frequently.

ASTROPHYSICS EXPLORER

Currently, there is one Astrophysics SMEX mission scheduled for launch in 2012: the Nuclear Spectroscopic Telescope Array (NuSTAR). The Gravity and Extreme Magnetism SMEX (GEMS) is in formulation. In 2011, NASA selected two missions for concept studies: First Infrared Exoplanet Spectroscopy Survey Explorer (FINESSE), and Transiting Exoplanet Survey Satellite (TESS).NASA selected two MOs for concept studies: Galactic/Xgalactic Ultra long duration balloon Spectroscopic Stratospheric THz Observatory (GUSSTO), and Neutron star Interior Composition ExploreR (NICER). NASA will make final selections in early 2013.

Other Missions and Data Analysis also supports the Astro-H Soft X-ray Spectrometer mission of opportunity, currently in development, as well as four previously launched Explorer missions, as they continue to produce world-class science in their extended mission phases. It also supports program management functions, and funding for future mission selections.

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

EXPLANATION OF MAJOR CHANGES FOR FY 2013

NASA created a dedicated Astrophysics program management line to manage the Explorer missions, which will be done in conjunction with the Heliophysics division.

BUDGET EXPLANATION

The FY 2013 request is $75.1 million. This represents a $37.1 million decrease from the FY 2012 estimate ($112.2 million). This change reflects planned reductions to workforce as GEMS, NuSTAR, and Astro-H near launch.

NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

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	**111.6**	**36.1**	**11.8**	**4.7**	**4.4**	**0.0**	**0.0**	**0.0**	**0.0**	**168.4**
Change From FY 2012 Est. ($M)		--	--	**-7.1**						
Percent Change From FY 2012 Est.		--	--	**-60.2%**						

The NuSTAR observatory is prepared for launch, and will make the first census of supermassive black holes throughout cosmic space and time. Using advanced mirrors that can focus much more energetic X-rays, NuSTAR, will image the densest, hottest, and most energetic regions in the Universe.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

NuSTAR launch is now planned for March 2012, contingent upon clearing the Pegasus launch vehicle for launch by late February 2012. NuSTAR received $3.7 million of additional funding between FY 2013 and FY 2014 for extended science operations and a guest investigator program.

PROJECT PURPOSE

The purpose of the NuSTAR mission is to observe the universe at high x-ray energy levels. By focusing higher energy x-rays, NuSTAR will start to answer fundamental questions about the universe including: How are black holes distributed through the cosmos? How were heavy elements forged in the explosions of massive stars? What powers the most extreme active galaxies?

NuSTAR's primary science goal is to make the first deep observations of regions of the sky in the high energy x-ray band. This will allow scientists to locate massive black holes in other galaxies, locate and examine the remnants of collapsed stars

NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

Formulation	Development	Operations

in our galaxy, observe selected very high energy gamma-ray sources, and observe any supernovae of opportunity in the local group of galaxies. NuSTAR's key science products will be sensitive high-energy x-ray survey maps of the celestial sky that will guide the x-ray astronomy community research for several years to come. In addition to its core science program, NuSTAR will offer opportunities for a broad range of science investigations, ranging from probing cosmic ray origins, to studying the extreme physics around collapsed stars, to mapping microflares on the surface of the Sun. NuSTAR will perform follow-up observations to discoveries made by Chandra and Spitzer scientists, and NuSTAR research teams will team with those using Fermi to make simultaneous observations.

PROJECT PARAMETERS

NuSTAR will image the sky in the high- energy x-ray band, 6 to 79 kiloelectronvolts, and the spacecraft will be three-axis stabilized. The primary science instruments will be two identical focusing x-ray telescopes that use an extendable 10 meter mast. The launch vehicle will be a Pegasus XL.

ACHIEVEMENTS IN FY 2011

The NuSTAR observatory completed thermal vacuum testing, vibration/acoustics testing, and electromagnetic interference testing in preparation for shipment to Vandenberg Air Force Base in January 2012.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

NuSTAR will conduct nominal science operations and data analysis.

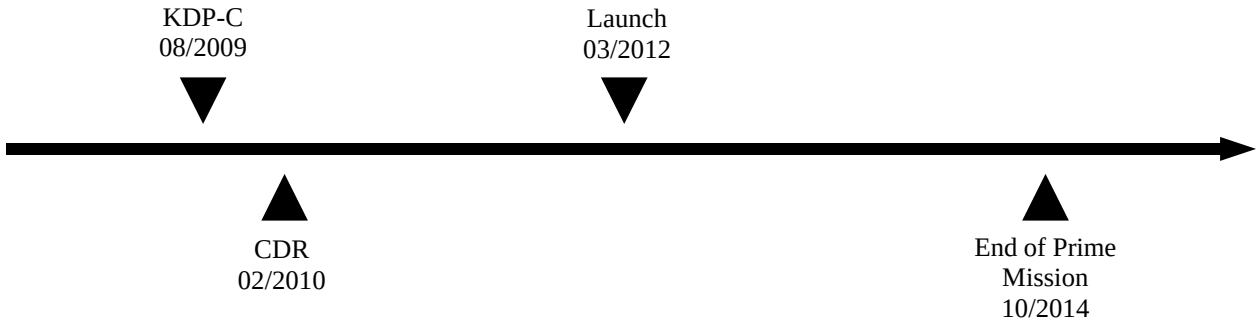
NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

Formulation	Development	Operations

SCHEDULE COMMITMENTS/KEY MILESTONES

Development Milestones	Confirmation Baseline Date	FY 2013 PB Request Date
KDP-C	Aug-09	Aug-09
CDR	Feb-10	Feb-10
Launch	Jan-12	Mar-12
End of Prime Mission	Sep-14	Oct-14

Project Schedule



NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

Formulation	Development	Operations

Project Management & Commitments

JPL is responsible for NuSTAR project management. The principal investigator at the California Institute of Technology is responsible for mission science.

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Spacecraft	Provider: Orbital Project Management: JPL NASA Center: JPL Cost Share: N/A	Spacecraft design, fabrication and testing.	Same	Same
Mission operations, focal plane assembly and instrument electronics	Provider: University of California, Berkeley Project Management: JPL NASA Center: Cost Share: N/A	Aperture stop, active shield module and mechanical enclosures	Same	Same
X-ray optics	Provider: Columbia University and the Danish Technical University Project Management: JPL NASA Center: GSFC Cost Share: N/A	Overall optics assembly management and manufacturing	Same	Same
Mast, canister and instrument structure	Provider: ATK Project Management: JPL NASA Center: GSFC Cost Share: N/A	Delivery of mast, canister and instrument structure for the spacecraft	Same	Same
Launch Vehicle	Provider: KSC Project Management: KSC NASA Center: KSC Cost Share: N/A	Pegasus XL	Same	Same

NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: the launch vehicle schedule is delayed beyond March 2011, Then: the project will incur increased mission costs.	Track launch vehicle status closely. Identify sources of funding to cover the potential cost increase.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

All major acquisitions are in place. NuSTAR was selected via a NASA Explorers AO.

Element	Vendor/Provider	Location
Spacecraft	Orbital	Dulles, VA
X-ray Optics	Columbia University	New York, NY
Mast and Canister	Alliant Techsystems	Arlington, VA

NUCLEAR SPECTROSCOPIC TELESCOPE ARRAY (NUSTAR)

Formulation	Development	Operations

INDEPENDENT REVIEWS

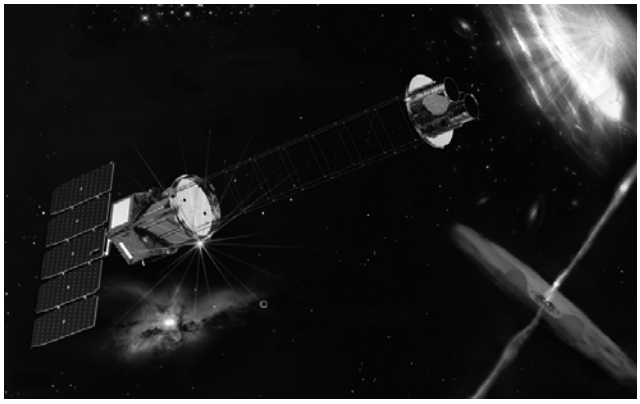
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	11-Jan	SIR. Evaluates the readiness of the project to start flight aseembly, test, and integration.	N/A
Performance	SRB	N/A	Operations Readiness Review. Examines the actual system characteristics and the procedures used in the system or product's operation and ensures that all system and support hardware, software, personnel, and procedures are ready for operations.	12-Feb

GRAVITY AND EXTREME MAGNETISM SMEX (GEMS)

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	**5.6**	**23.0**	**63.2**	**46.4**	**32.9**	**2.7**	**0.2**	**0.0**
Change From FY 2012 Estimate		--	--	**-16.8**				
Percent Change From FY 2012 Estimate		--	--	**-26.6%**				



Some of the fundamental questions scientists hope GEMS will answer include: Where is the energy released near black holes? Where do the X-ray emissions from pulsars and neutron stars originate? What is the structure of the magnetic fields in supernova remnants?

PROJECT PURPOSE

The Gravity and Extreme Magnetism SMEX (GEMS) mission will explore the edges of space-time in the vicinity of black holes and test the extreme physics of compact objects that are formed at the end of normal stellar lives. GEMS will use an X-ray telescope to explore how space is distorted by a spinning black hole's gravity, and probe the structure and effects of the formidable magnetic field around magnetars, dead stars with magnetic fields trillions of times stronger than that of Earth. These studies will illuminate the destiny of stars, and probe the accelerators of cosmic ray particles. GEMS will be better able to tell the shapes of the x-ray-emitting matter trapped near black holes than existing or prior missions by measuring polarization of the x-rays at least ten times better than previous experiments.

EXPLANATION OF MAJOR CHANGES FOR FY 2013

The GEMS mission is still in formulation with an expected launch readiness date of November 2014.

GRAVITY AND EXTREME MAGNETISM SMEX (GEMS)

Formulation	Development	Operations

PROJECT PRELIMINARY PARAMETERS

The nominal science mission is nine months in duration. The X-ray Polarimeter Instrument (XPI) consists of two identical, co-aligned telescopes with detectors that will be sensitive from 2 to 10 kiloelectronvolts and able to detect polarization amplitude and angle of observed x-rays. The orbit altitude is 575 kilometers with an inclination of 28.5 degrees.

ACHIEVEMENTS IN FY 2011

NASA completed the PDR for the GEMS spacecraft. NASA expects to complete mission PDR in February 2012.

KEY ACHIEVEMENTS PLANNED FOR FY 2013

The GEMS project will be in implementation phase in FY 2013 if it successfully passes KDP-C planned for April 2012. During implementation, the polarimeter instrument will be delivered to the spacecraft to begin integration and testing.

ESTIMATED PROJECT SCHEDULE

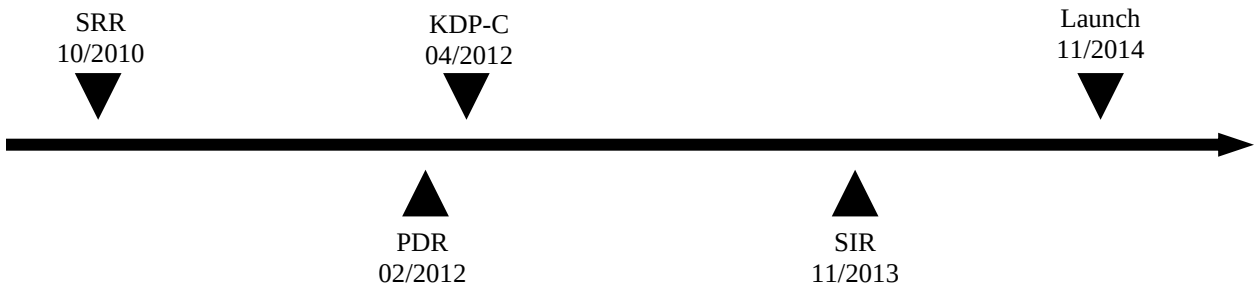
GEMS is planned for a launch in November 2014 for a nine-month prime mission.

Formulation Milestones	Formulation Agreement Estimate	FY 2013 PB Request Date
Formulation Authorization	Oct-09	Oct-09
SRR	Jun-10	Oct-10
SIR	May-13	Nov-13
PDR	Aug-11	Feb-12
KDP C	Jul-11	Apr-12
Launch	Apr-14	Nov-14

GRAVITY AND EXTREME MAGNETISM SMEX (GEMS)

Formulation	Development	Operations

Project Schedule



Formulation Estimated Life Cycle Cost Range and Schedule Range Summary

KDPB Date	Estimated Life Cycle Cost Range ($M)	Key Milestone	Key Milestone Estimated Date Range
9-Jun	173.8 - 230	Launch	Nov-14 - Sep-15

GRAVITY AND EXTREME MAGNETISM SMEX (GEMS)

Formulation	Development	Operations

Project Management & Commitments

Project/Element	Provider	Description	FY 2012 PB Request	FY 2013 PB Request
Project and Science Management	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: N/A	Project manager, principal investigator, and project scientist	Same	Same
Spacecraft	Provider: Orbital Sciences Corporation Project Management: ARC NASA Center: None Cost Share: N/A	Spacecraft design, fabrication and testing	Same	Same
X-ray Polarimeter Instrument (XPI)	Provider: GSFC Project Management: GSFC NASA Center: GSFC Cost Share: N/A	It comprises two telescopes which focus source flux into photoelectric polarimeters which employ a time projection chamber readout geometry	Same	Same
Launch Vehicle	Provider: KSC Project Management: KSC NASA Center: KSC Cost Share: N/A	Pegasus-class launch vehicle	Same	Same

GRAVITY AND EXTREME MAGNETISM SMEX (GEMS)

Formulation	Development	Operations

Project Risks

Risk Statement	Mitigation
If: Orbital's final costs are higher than the phase C/D/E proposal, Then: there will be cost overruns.	Tracking release of Orbital subcontracts as they are finalized. Current OSC phase C/D/E contract is under negotiation.

Acquisition Strategy

MAJOR CONTRACTS/AWARDS

Element	Vendor/Provider	Location
Spacecraft, Observatory I&T and Launch Site Campaign, Mission Operations Center	Orbital Science Corporation	Dulles, VA

GRAVITY AND EXTREME MAGNETISM SMEX (GEMS)

Formulation	Development	Operations

INDEPENDENT REVIEWS

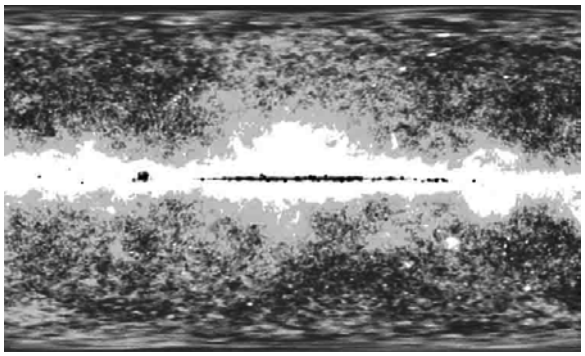
Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SRB	N/A	PDR. Determine if the project is ready to proceed into development.	Feb-12
Performance	SMD Directorate Mission Program Council	N/A	Confirmation Review (KDP-C). Determine whether to give the project the authority to proceed into the development phase	Apr-12
Performance	SRB	N/A	SIR. Evaluates the readiness of the overall system to commence integration and testing.	Nov-13

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	**41.0**	**37.2**	**24.1**	**97.1**	**131.2**	**156.8**	**165.6**
Astro-H (SXS)	16.9	16.2	4.4	1.8	1.0	0.9	0.0
Astrophysics Explorer Future Missions	0.0	3.1	10.6	85.6	124.0	149.6	159.3
Astrophysics Explorer Program Management	0.0	7.3	4.1	5.3	6.2	6.3	6.4
Wide-Field Infrared Survey Explorer	7.3	4.5	**0.2**	0.0	0.0	0.0	0.0
SWIFT	6.3	4.3	4.4	4.4	0.0	0.0	0.0
Suzaku (ASTRO-E II)	1.8	0.3	0.3	0.0	0.0	0.0	0.0
Rossi X-Ray Timing Explorer	0.9	0.0	0.0	0.0	0.0	0.0	0.0
GALEX	6.2	0.6	0.0	0.0	0.0	0.0	0.0
Wilkinson Microwave Anistropy Probe	1.6	1.0	**0.0**	0.0	0.0	0.0	0.0
Change From FY 2012 Estimate	--	--	**-13.1**				
Percent Change From FY 2012 Estimate	--	--	**-35.3%**				



NASA's Wilkinson Microwave Anisotropy Probe has mapped the cosmic microwave background radiation (the oldest light in the universe) and produced the first fine-resolution (0.2 degree) full-sky map of the microwave sky.

Astrophysics Explorers program provides frequent flight opportunities for world-class scientific investigations from space utilizing innovative, streamlined and efficient management approaches within the Heliophysics and Astrophysics science areas. This budget funds Astrophysics missions already in operation and supports future mission selections.

Non-Operating Missions

ASTROPHYSICS EXPLORER FUTURE MISSIONS

Astrophysics Explorer Future Missions funding supports future Explorer missions and missions of opportunity through concept studies and selections.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

ASTROPHYSICS EXPLORER PROGRAM MANAGEMENT

Astrophysics Explorer program management provides programmatic, technical, and business management of ongoing missions in formulation and development.

Operating Missions

THE WIDE-FIELD INFRARED SURVEY EXPLORER (WISE)

WISE is a Medium Explorer class mission that launched in December 2009. It has surveyed the entire sky in four mid-infrared bands and mapped it with better sensitivity than previous infrared all-sky surveys. During its six-month mission, WISE mapped the sky in infrared light, searching for the nearest and coolest stars, the origins of stellar and planetary systems, and the most luminous galaxies in the universe. Its legacy is a rich database that will enable astronomers to address questions posed by the Cosmic Origins program. WISE's infrared survey provided an essential catalog for JWST. NASA is currently finishing final WISE data verification, with a final catalog release expected in March 2012.

SWIFT

Swift is a medium explorer class mission that launched in 2004 and is now in extended mission operations. It is a multi-wavelength space-based observatory that studies the position, brightness, and physical properties of gamma-ray bursts. Swift was designed to instantly respond to transient events, allowing identification and follow-up across many parts of the electromagnetic spectrum. This ability also allows extremely flexible and efficient observing of astronomical objects.

Swift is in extended operations through FY 2012. Senior Review results will determine operations in FY 2013 and beyond

SUZAKU

Suzaku is Japan's fifth x-ray astronomy mission, which launched in July 2005. It was developed at the Institute of Space and Astronautical Science of Japan Aerospace Exploration Agency (ISAS/JAXA) in collaboration with U.S. (NASA/GSFC, Massachusetts Institute of Technology) and Japanese institutions. NASA provides software to analyze Suzaku data and operates a Guest Observer Facility for U.S. observers.

OTHER MISSIONS AND DATA ANALYSIS

Formulation	Development	Operations

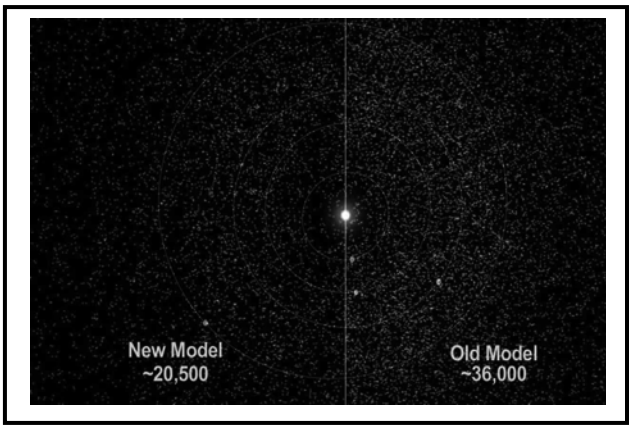
Suzaku is a powerful orbiting observatory for studying extremely energetic processes in the universe. Sensitive x-ray spectrometers enable precise measurements of high-energy processes in stars, supernova remnants, galaxies, clusters of galaxies, and the environments around neutron stars and black holes. Suzaku is in extended operations through FY 2012. Senior Review results will determine support in 2013

ASTRO-H (SXS)

Astro-H (SXS) is a mission of opportunity, currently in development, through which NASA will provide the High-Resolution Soft X-Ray Spectrometer (SXS) instrument. Astro-H SXS is scheduled for a 2014 launch onboard the Japanese Astro-H –IIA spacecraft. The observatory will carry a suite of four science instruments spanning virtually the entire x-ray energy band. The SXS instrument is a cryogenically cooled high-resolution x-ray spectrometer that will allow the most detailed studies of the high-energy spectra of a wide range of astronomical systems from nearby stars to distant active galaxies. Using this unprecedented capability, the mission will conduct a number of fundamental studies, including tracing the growth history of the largest structures in the universe, obtaining insights into the behavior of material in extreme gravitational fields, determining the spin of black holes, probing shock acceleration structures in clusters of galaxies, and investigating the detailed physics of jets.

Recent Achievements

WISE COMPLETES ASTEROID SURVEY



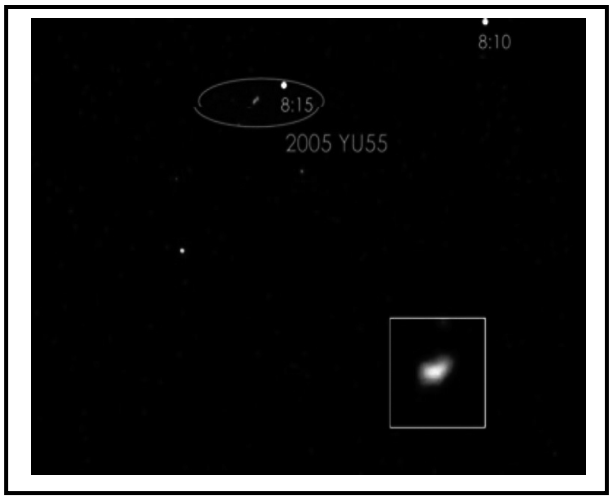
New observations by WISE show there are significantly fewer near-Earth asteroids in the mid-size range than previously thought. The findings also indicate NASA has found more than 90 percent of the largest near-Earth asteroids, thereby accomplishing a task mandated by Congress in 1998.

Astronomers now estimate there are roughly 19,500, not 35,000, mid-size near-Earth asteroids. Scientists say this improved understanding of the population may indicate the hazard to Earth could be somewhat less than previously thought. However, the majority of these mid-size asteroids remain to be discovered. More research also is needed to determine if fewer mid-size objects (between 330 and 3,300-feet wide) also mean fewer potentially hazardous asteroids, those that come closest to Earth.

The results come from the most accurate census to date of near-Earth asteroids, the space rocks that orbit within 120 million miles (195 million kilometers) of the sun into Earth's orbital vicinity. WISE observed

infrared light from those in the middle to large-size category. The survey project, called NEOWISE, is the asteroid-hunting portion of the WISE mission.

SWIFT DOES DOUBLE DUTY



As asteroid 2005 YU55 swept past Earth in the early morning hours of Wednesday, November 9, 2011, telescopes aboard NASA's Swift satellite joined professional and amateur astronomers around the globe in monitoring the fast-moving space rock. The unique ultraviolet data will aid scientists in understanding the asteroid's surface composition. Although Swift is better known for studies of high-energy outbursts and cosmic explosions, the versatile satellite has made valuable observations of passing comets and asteroids as well. All told, the spacecraft has observed ten asteroids, including Vesta, which is now being studied close-up by NASA's Dawn spacecraft, and Scheila, which brightened unexpectedly in late 2010 after colliding with a much smaller asteroid.