Mission Directorate:	Science
Theme:	Earth Science

Theme Overview

NASA's Earth Science Theme supports breakthrough research to advance fundamental knowledge on the most important scientific questions on the global and regional integrated Earth system. NASA's activities encompass the global atmosphere; the global oceans including sea ice; land surfaces including snow and ice; ecosystems; and interactions between the atmosphere, oceans, land, and ecosystems, including humans. NASA's goal is to understand the Earth system and the changing climate and, in association with national and international partners, apply this understanding for the well-being of society. A key strategic element is sustained simultaneous observations to unravel the complexity of the global integrated Earth system.

NASA accomplishes its goals through continuous interactions among its four major elements: Flight Programs develops satellite missions; Research and Analysis redeems the investment in measurements by advancing scientific understanding, while also identifying the foci for the next generation of missions; Technology develops new technology and enables the next generation of effective satellite and airborne instruments; and, Applied Sciences advances the rapid and effective use of ESD measurements and scientific understanding by other Federal, state, local and tribal organizations.

NASA operates fifteen satellite missions that make well-calibrated global observations with high-spatial and high-temporal resolution. NASA aircraft- and surface-based instruments calibrate, complement, and enhance interpretation of satellite measurements. NASA supports state-of-the-art computing capability and capacity for global integrated Earth system modeling. NASA missions produce nearly 4 terabytes of data every day, and NASA maintains the world's largest scientific data and information system for collecting, processing, archiving, and distributing Earth system data to worldwide users.

NASA has five missions in formulation and development. Two Decadal Survey missions have preliminary launch readiness dates of late 2013/early 2014 and late 2014/early 2015, and other Decadal Survey missions are in pre-formulation studies.

Seven in-orbit satellite missions provide data in near-real time to the National Oceanic and Atmospheric Administration for operational forecasts of weather, hurricanes, air quality, and harmful algal blooms. Ten of the in-orbit missions are conducted with fourteen international partners

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	**1,237.4**	**1,704.6**	**1,405.0**	**1,500.0**	**1,550.0**	**1,600.0**	**1,650.0**
Earth Science Research	358.3	437.4	397.5	407.5	404.2	416.8	412.1
Earth Systematic Missions	546.1	898.9	715.5	725.4	786.4	818.8	867.6
Earth System Science Pathfinder	106.8	118.3	63.9	128.8	114.2	121.4	119.1
Earth Science Multi-Mission Operations	143.0	148.1	149.9	160.3	165.4	161.3	165.5
Earth Science Technology	43.0	54.1	45.9	47.2	48.2	49.5	52.7
Applied Sciences	40.2	47.8	32.2	30.7	31.5	32.2	33.1
FY 2009 President's Budget Request	**1,280.3**	**1,367.5**	**1,350.7**	**1,250.9**	**1,264.4**	**1,290.3**	**--**
Earth Science Research	375.8	380.6	388.2	390.6	400.7	409.3	--
Earth Systematic Missions	530.1	677.9	661.5	583.2	563.6	569.6	--
Earth System Science Pathfinder	113.8	88.6	58.8	37.4	50.0	54.9	--
Earth Science Multi-Mission Operations	167.8	140.5	159.1	157.9	166.5	170.9	--
Earth Science Technology	47.3	46.1	49.2	50.6	51.6	52.8	--
Applied Sciences	45.4	33.8	33.8	31.3	32.1	32.8	--
Total Change from FY 2009 Request	**-42.9**	**337.0**	**54.3**	**249.1**	**285.6**	**309.7**	**--**

Note: Includes $325M of Recovery Act funding in FY09. Starting in FY 10, the NEOO project is in the Planetary theme.

Plans for FY 2010

Earth Science Research

As a result of the funding provided by the American Recovery and Reinvestment Act of 2009, and a significant commitment by the new Administration to Earth Science in FY2010-14, NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat I and ICESat II data. This activity, focusing on changes in Greenland and arctic ice, will continue in FY 2010 and beyond.

The Science Mission Directorate will issue Research Opportunities in Space and Earth Science 2009 (ROSES-09), a research announcement covering all of the planned research solicitations in Earth Science Research for FY 2009; the FY 2010 budget will fund the competitively selected activities. Roughly a third of the Earth Science Research budget is competed each year through ROSES. The resulting grants are generally funded for three years following the selections. Given the average of a three-year funding cycle, many of the research activities carried out in FY 2010 will be tasks initiated in FY 2008 and FY 2009 based on solicitations included in ROSES-07 and ROSES-08, respectively. Selections based on ROSES 08 solicitations are on-going and are addressing a number of Earth Science research areas, including ocean circulation, the effect of decreasing sea ice cover on climate, energy and water cycle, arctic research of the composition of the troposphere, geodetic imaging, global modeling of the Earth System, hurricane science and biodiversity (first-ever NASA research solicitation). In addition the Research Program develops and tests experimental techniques and algorithms that contribute to future Decadal Survey missions.

Earth Systematic Missions

As a result of the funding provided by the American Recovery and Reinvestment Act of 2009, and a significant commitment by the new Administration to Earth Science in FY 2010-14, significant progress can be made towards the goals identified in the National Research Council (NRC) 2007 report, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond". The Soil Moisture Active-Passive (SMAP) and Ice, Cloud, and Land Elevation Satellite (ICESat II) missions will be pursued aggressively, leading to projected launches in late 2013/early 2014 and late 2014/ early 2015 respectively. Studies of the next two Decadal Survey missions, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI), will also intensify.

NASA has also begun development of the Thermal Infrared Sensor (TIRS) instrument, which is now fully funded within the LDCM Project.

The following other activities will be undertaken in FY 2010:

- GPM will complete its Preliminary Design Review followed by Confirmation Review and KDP-C,
- NPP will complete its satellite pre-environmental review,
- Glory will have its Launch Readiness Review, followed by the launch of the spacecraft, and
- LDCM will complete its instrument Critical Design Review and Mission Critical Design Review.

All operating missions will be a part of the 2009 Senior Review, to determine whether extended operations are warranted.

Plans for FY 2010

Earth System Science Pathfinder

Aquarius/SAC-D observatory will have completion of environmental testing, Operational Readiness Review and mission launch. All operating missions will be reviewed during the 2009 Senior Review process to determine whether extended operations are warranted.

NASA is determining how best to meet the lost science contribution after the Orbiting Carbon Observatory (OCO) launch vehicle failure. We have initiated studies to examine both science and hardware considerations. The science study is assessing the current state of carbon cycle science and existing measurements to see what course of action would best address the key science issues. On the hardware side, NASA is examining reflight opportunities, including, but not limited to, flying an OCO-like instrument on a shared platform or as a dedicated mission.

In response to the NRC report, NASA is initiating a new series of competed "Venture-class" missions. These missions, which may include suborbital payloads, instruments to be flown on non-NASA spacecraft, or small dedicated spacecraft, will be selected via an Announcement of Opportunity. Selection of the first Venture-class mission(s) is planned for FY 2010.

Earth Science Multi-Mission Operations

The Earth Science Multi-Mission Operations Program will continue the operation of the Earth Observing System Data and Information System (EOSDIS), the Distributed Active Archive Centers (DAACs) and its accompanying functions, as well as Core System Science Data Processing Systems. The maintenance of these systems is important to the collection of data from Earth Science satellites in orbit, as well as to the continuity of Earth Science research efforts.

Step 1 of the 'Evolution of EOSDIS Elements' (EEE) effort, begun in 2006, is essentially complete. Savings and operational benefits from Step 1 are fully appreciated starting in FY 2009 and beyond. Between now and 2015, NASA plans to continue the support of the EEE to enable a service-oriented architecture (SOA), which allows different applications to exchange data with one another.

Five-year Making Earth Science Data Records for Use in Research Environments (MEaSUREs) Projects began work in 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. A new ACCESS solicitation is being readied for NASA's Research Opportunities in Space and Earth Sciences - 2009 (ROSES-2009). These Cooperative Agreements are proving very valuable for keeping research and modeling communities actively involved with the EOSDIS architecture, and informing core infrastructure evolution decisions.

Earth Science Technology

The Earth Science Technology Program (ESTP) will develop new remote-sensing and information systems technologies for infusion into future science missions to enable, or dramatically enhance, measurements and data system capabilities. Planning will start with measurement priorities established by the science community, leading to systematically developed technology requirements and priorities. Studies may be conducted to assess the most effective ways to meet technology performance requirements. Tasks will be awarded through competed solicitations in the three project areas: Instrument Incubator, Advanced Information Systems, and Advanced Technology Initiatives.

Plans for FY 2010

Applied Sciences

The Applied Sciences Program will continue to work across the range of application areas, with special focus on supporting communities as they plan for and respond to the impacts of climate change.

In October 2008, the NASA Applied Sciences Program completed a comparison study of seven Federal programs that incorporate Earth science data into decision making activities for policy and management. The Applied Sciences Program used this study to identify best practices and to benchmark its approaches on strategic planning, implementation, partnership development, and administration. The study concluded that that Applied Sciences Program is "unique with individual drivers, processes, and expectations." The study suggested that longer-term relationships with users provide a source of innovation in applications; that applied research is often needed to make science results more robust for use in applications; and that diversified funding portfolios, multi-disciplinary staffing, and defined project end-points are keys to successful applications. The Applied Sciences Program has incorporated key findings in its FY2009-2014 Program Plan.

Relevance

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

The 2008 NASA Authorization Act and 2006 National Space Policy charged NASA to develop unique capabilities in global Earth observations and models to discover fundamental scientific knowledge of the integrated Earth system. NASA activities contribute substantially to two Presidential Initiatives ' Integrated Global Earth Observations and Ocean Action Plan; three Congressional Initiatives ' National Oceanographic Partnership Program, Global Change Research Act, and Clean Air Act Amendments; and, two United Nations Assessments ' Intergovernmental Panel on Climate Change and Ozone Depletion. NASA is the largest funding contributor to the 13-agency U.S. Climate Change Science Program.

NASA coordinates with the U.S. Geological Survey on the Landsat Data Continuity Mission and with the Department of Defense and National Oceanic and Atmospheric Administration (NOAA) on the National Polar-orbiting Operational Environmental Satellite System. NASA develops, on a reimbursable basis with NOAA, the Geostationary Operational Environmental Satellite and Polar Orbiting Environmental Satellite programs. In FY 2009, NASA and the French space agency declared the Ocean Surface Topography Mission to be operational and transferred satellite command and control operations to NOAA, marking an important milestone in the transition of a research satellite measurement capability to an operational capability.

Relevance to the NASA Mission and Strategic Goals:

Earth Science supports NASA's achievement of Strategic Plan Sub-Goal 3A: "Study Earth from space to advance scientific understanding and meet societal needs."

This effort is comprised of seven Outcomes:
3A.1: Progress in understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition.
3A.2: Progress in enabling improved predictive capability for weather and extreme weather events.
3A.3: Progress in quantifying global land cover change and terrestrial and marine productivity, and in improving carbon cycle and ecosystem models.
3A.4: Progress in quantifying the key reservoirs and fluxes in the global water cycle and in improving models of water cycle change and fresh water availability.
3A.5: Progress in understanding the role of oceans, atmosphere, and ice in the climate system and in improving predictive capability for its future evolution.
3A.6: Progress in characterizing and understanding Earth surface changes and variability of Earth's gravitational and magnetic fields.
3A.7: Progress in expanding and accelerating the realization of societal benefits from Earth system science.

Earth Science researchers seek to answer how and why the global integrated Earth system is changing, how it supports life, how life impacts the Earth system, and how this information will benefit the Nation.

See FY 2010 Performance Plan for specific annual goals.

Relevance to education and public benefits:

NASA develops innovative programs to educate and train scientists in understanding the global integrated Earth system and infuse NASA observations and scientific results in the public and all venues of learning. The DEVELOP program (not an acronym) is a national high school and university student-led, student-run internship activity. ESD's Earth System Science Fellowship Program trains graduate students, while the New Investigator Program targets early-career scientists and engineers. NASA Earth Science discoveries are reported almost daily through the world's media to motivate students and young scientists to pursue challenging careers in Earth science and technology.

NASA Earth Science improves public understanding of the complexity of the global integrated Earth system. Guided primarily by the 2007 National Research Council Decadal Survey, NASA is executing an ambitious plan to answer questions regarding why and how the environment is changing, define the impacts of environmental change on humans, and identify how humans can mitigate the impact of environmental hazards. Through its work with other Federal agencies to improve their operational services, NASA Earth Science advances capabilities in such areas as weather and air quality forecasting, climate prediction, and natural hazard and land use assessment.

Performance Achievement Highlights:

- Arctic Ocean Climate. In September 2007, NASA Aqua satellite measurements revealed that Arctic Ocean sea ice coverage was 23% smaller compared to the previous minimum extent in September 2005. One year later in September 2008, the coverage was the second lowest recorded since 1978, when satellite sea ice observations began with NASA's Nimbus-7 satellite. In 2008, NASA-supported researchers explained the complex causes and impacts of rapid summertime Arctic sea ice depletion. NASA ICESat satellite data revealed Arctic sea ice was becoming thinner, making it easier to melt in summer. Over the western Arctic Ocean where most of the increased melt occurred in 2007, the NASA CloudSat satellite showed decreased cloud cover relative to 2006 and the NASA Aqua satellite measured increased incident solar radiation. The NASA SeaWiFS data-buy product showed that reduced summertime sea ice coverage lengthened the growing season for near-surface ocean phytoplankton, which increased the phytoplankton abundance in the Arctic Ocean.

-Global Air Pollution. NASA Aura satellite measurements tracked air pollutants from their generation sites to assess air quality throughout the world. In 2008, NASA researchers announced the first measurement-based estimate of pollution traveling from East Asian forest fires, urban exhaust and industrial production to North America. About 450 million kilograms of small particle (aerosol) pollution reached the northwest coast of Canada and the United States.

-New Technology. NASA's unmanned aerial system Ikhana, equipped with an innovative NASA Autonomous Modular Sensor instrument, transmitted real-time measurements of visible, infrared and thermal imagery directly to firefighting control centers to monitor and predict the trajectory of California's wildfires. The Secretary of the U.S. Department of Homeland Security and the Governor of California recognized NASA's contributions to prevent loss of life and property.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NASA Advisory Council (NAC)	05/2008	NASA Advisory Council (NAC) - Review science strategy and implementation strategy for the Earth Science programs	05/2009
Relevance	National Research Council	01/2007	National Research Council - Decadal Survey of effectiveness and quality of the Earth Science programs. First time a Decadal Survey was developed for Earth Science.	2016

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	358.3	437.4	397.5	407.5	404.2	416.8	412.1
Earth Science Research and Analysis	259.4	313.7	281.7	300.3	294.2	304.4	296.5
Computing and Management	98.9	123.7	115.8	107.2	110.0	112.4	115.6
FY 2009 President's Budget Request	372.5	376.9	384.5	386.8	396.8	405.3	--
Earth Science Research and Analysis	269.3	271.9	279.7	279.4	286.7	293.5	--
Computing and Management	103.1	104.9	104.7	107.3	110.1	111.8	--
Changes from FY 2009 Request	-14.2	60.6	13.1	20.8	7.5	11.6	--

Note: Includes $68.5M of Recovery Act funding in FY09

Program Overview

The Earth Science Research Program advances our knowledge of the global distribution of a range of important environmental parameters related to the Earth's atmosphere, hydrosphere, biosphere, cryosphere, and land surface; to understand the processes that drive and connect them; and to improve our capability to predict the future evolution of the Earth system, including climate, weather, and natural hazards.

Earth Science Research funds basic research and modeling efforts, the Airborne Science Project (which conducts research using airplanes and Uninhabited Air Systems), supercomputing efforts that support a variety of agencies, and education and outreach.

For more information, please see http://science.hq.nasa.gov/earth-sun/index.html.

Plans For FY 2010

The research program portfolio is highly diverse in terms of activities sponsored as described for each project in the following section.

As a result of the funding provided by the American Recovery and Reinvestment Act of 2009, and a significant commitment by the new Administration to Earth Science in FY2010-14, NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat I and ICESat II data. This activity, focusing on changes in Greenland and arctic ice, will continue in FY 2010 and beyond.

The R&A project constitutes the core of the program and accounts for roughly half of the total budget. It is mostly competed via the Science Mission Directorate Research Opportunities in Space and Earth Science 2009 (ROSES-09), a research solicitation released February 2009. Solicited research in 2009 will generally result in grants funded with FY10 funding and two subsequent years, and includes ocean biology and biogeochemistry, terrestrial ecology, physical oceanography, atmospheric composition, and a hurricane field experiment. It will also continue funding research solicited in ROSES-08 and ROSES-07 as they have progressed in their 2nd and 3rd year, respectively. The research portfolio includes the Interdisciplinary Science project, also competed in ROSES-09 with the focus to continue funding research in interdisciplinary areas, such as sea level change, water and energy cycle impacts of biomass burning and integrated earth system responses to extreme disturbances. Other competitive grant projects are the carbon cycle science team (continued from previous selection) and the Earth science education and outreach activity (also in ROSES-09). The remaining activities include primarily directed funding to NASA Centers for space geodesy (funding the development and operation of the geodetic networks), high end computing, scientific computing and global modeling and data assimilation.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

Project Descriptions and Explanation of Changes

Earth Science Research and Analysis

The Earth Science Research Program area consists of multiple projects and science teams which support the overall diverse R&A goals:

Research and Analysis Project:
The Earth Science Research and Analysis (R&A) Project is the core of the R&A Program and funds research in all six Earth Science focus areas: 1) Climate variability and change; 2) Atmospheric composition; 3) Carbon cycle, ecosystems, and biogeochemistry; 4) Water and energy cycles; 5) Weather; and 6) Earth surface and interior. Additionally, the R&A Project addresses the Earth system and the interactions of its components, characterizing them on a broad range of spatial and temporal scales to understand the naturally occurring and human-induced processes that drive the overall system.

Airborne Science:
Airborne Science funds NASA's manned airplanes, and Uninhabited Air Systems (UAS) based Earth science efforts. The project supports the operation of a catalog of NASA-owned and leased aircraft, including the ER-2, DC-8, WB-57, P-3, Twin Otter, B-200, Aerosonde, Global Hawk, and other UAS aircraft. These assets are deployed in campaigns conducted around the world to monitor extreme weather events (e.g., hurricanes), capture data for Earth science modeling activities, and calibrate the instruments flying aboard Earth science spacecraft. As mentioned above, and as a result of the funding provided by the American Recovery and Reinvestment Act of 2009, and a significant commitment by the new Administration to Earth Science in FY2010-14, NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat I and ICESat II data. This activity, focusing on changes in Greenland and arctic ice, will continue in FY 2010 and beyond.

Interdisciplinary Science:
Interdisciplinary Science funds science teams, as well as calibration and validation activities, that ensure the utility of spaceborne measurements. In addition, it supports focused field work (e.g. airborne campaigns) and specific facility instruments, which are heavily relied upon in fieldwork.

Carbon Cycle Science Team:
The Carbon Cycle Science Team conducts research on the distribution and cycling of carbon among the Earth's active land, ocean and atmospheric reservoirs.

Global Modeling and Assimilation Office:
The Global Modeling and Assimilation Office, located at Goddard Space Flight Center, creates global climate and environmental models using data from Earth science satellites and aircraft. These products can then be used by investigators worldwide to further their research.

Ozone Trends Science:
The Ozone Trends Science project has an overall goal of producing a consistent, calibrated ozone time series that can be used for trend analyses and other studies.

Earth Science Research and Analysis (continued)

Education and Outreach Activity:
The Education and Outreach Activity supports NASA educational outcomes and communicates the results from Earth science missions and research through competitively selected projects. It also continues the worldwide implementation and U.S. coordination of the Global Learning and Observations to Benefit the Environment (GLOBE) Program, in partnership with the National Science Foundation.

Fellowships and New Investigators:
The Fellowships and New Investigators project supports graduate and early-career research, respectively, that is relevant of Earth system research and applied science.

Space Geodesy:
The Space Geodesy Project provides global geodetic positioning and supports the establishment of the needed geodetic reference frames in support of climate change and geohazards research and applications and their associated missions.

Computing and Management

The Computing and Management area consists of three projects:

High-End Computing Capability (HECC):
The High-End Computing Capability (HECC) project at Ames Research Center is focused around the Columbia supercomputer and the associated network connectivity, data storage, data analysis and visualization, and application software support. The Science Mission Directorate currently funds and manages the HECC resources, which serves the supercomputing needs of all NASA Mission Directorates as well as principle investigators at universities. Science Mission Directorate funding supports the operation, maintenance, and upgrade of NASA's supercomputing capability, while the Strategic Capabilities Assets Program exercises the oversight and insight functions. In 2008, a new approximately 40,000 processors supercomputer system "Pleiades" was acquired. The new system,currently ranked the world's third fastest supercomputer, supports NASA's aeronautics, exploration, space operation and science missions.

Scientific Computing:
Scientific Computing funds NASA's Earth Science "Discover" computing system, software engineering, and user interface projects at Goddard Space Flight Center. The Scientific Computing Project's primary purpose is to support Earth science modeling activities based on data collected by Earth science spacecraft.

Directorate Support:
The Directorate Support Project is the institutional budget for the Science Mission Directorate. It funds Headquarters institutional activities that impact the Mission Directorate (i.e. Space Studies Board, NASA Peer Review, printing and graphics, IT budget, NASA Postdoctoral Program, working group support, independent assessment studies, and other administrative tasks with Mission Directorate impact).

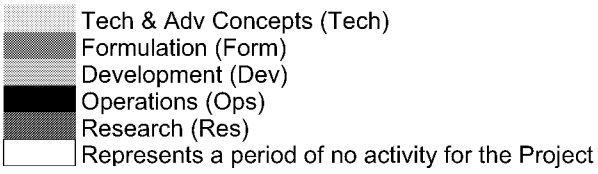
Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Issue competed, peer-reviewed research awards.	Research and Analysis; Airborne Science (flight opportunities)	None.
Maximize resource utilization (i.e., computing cycles) in supercomputer projects.	Scientific Computing; HECC	None.
Initiate the first-ever competitively selected science team.	Glory Mission of ESM Program; science team will be within R&A Program.	New solicitation in ROSES 2009 subelement.
Competitively selected airborne mission teams.	Tropical photochemistry and Aerosol Airborne Campaign - R&A	Solicitation in ROSES 2009 subelement.
Competitively selected airborne mission teams.	Hurricane Field Experiment - R&A	Solicitation in ROSES 2009 subelement.

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22		Beg	End
R&A, IDS Science, Carbon Cycle Science, Ozone Trends, Global Modeling and Assimilation Office, Space Geodesy, Education and Outreach, and Fellowships & New Investigators (all ongoing research efforts)																	Tech Form Dev Ops Res	Jan-90	Dec-20
Airborne Science																	Tech Form Dev Ops Res	Jan-90	Dec-20
Scientific Computing																	Tech Form Dev Ops Res	Jan-95	Dec-20
HECC																	Tech Form Dev Ops Res	Jan-05 Sep-05	Aug-05 Dec-20



Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

Program Management

The Earth Science Theme manages the Research Program. GSFC implements Scientific Computing and ARC implements HECC.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
R&A	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	Climate Change Science Program (CCSP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies
Interdisciplinary Science	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	Climate Change Science Program (CCSP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies
Carbon Cycle Science Team	Earth Science Theme, Science Mission Directorate	GSFC, JPL, ARC	Climate Change Science Program (CCSP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies
Ozone Trends Science	Earth Science Theme, Science Mission Directorate	GSFC and LaRC	Climate Change Science Program (CCSP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies.
Airborne Science	Earth Science Theme, Science Mission Directorate	GSFC/Wallops Flight Facility, DFRC, and ARC are the primary Centers involved in this project.	The Federal Aviation Administration, the Department of Defense, the Department of Energy, the National Science Foundation, and the National Oceanic and Atmospheric Administration (Department of Commerce).
High-End Computing Capability	Earth Science Theme, Science Mission Directorate	NASA Advanced Supercomputing, Ames Research Center	Department of Energy and the Department of Defense.
Scientific Computing	Earth Science Theme, Science Mission Directorate	NASA Center for Computational Sciences, Goddard Space Flight Center	Department of Energy and the Department of Defense.
Global Modeling and Assimilation Office (formerly Data Assimilation Office)	Earth Science Theme, Science Mission Directorate	Goddard Space Flight Center	None.
Space Geodesy	Earth Science Theme, Science Mission Directorate	Goddard Space Flight Center and Jet Propulsion Laboratory	None.
Earth Science Education and Outreach Activity	Science Mission Directorate	N/A (various non-NASA organizations)	National Science Foundation's Component of the Global Learning and Observations to Benefit the Environment (GLOBE).
Fellowships and New Investigators	Science Mission Directorate	N/A (various non-NASA organizations)	None.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Research

Acquisition Strategy

The Earth Science Research Program is based on full and open competition. Grants are peer reviewed and selected based on NASA Research Opportunities in Space and Earth Sciences (ROSES)and other related announcements.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NAC Earth Science Subcommittee	2008	The NASA Advisory Council Science Subcommittee reviews content and progress towards Earth Science sub-goal in the NASA Strategic Plan of at least one Science Focus Area per year. During its 2008 meeting, the ESS reviewed and rated the ESD Science Metrics based on the submitted accomplishments and peer-reviewed publications for FY2008. All six Science Focus Area metrics were rated "green" as documented in the FY2008 Annual Performance Report (APR).	2009

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Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	546.1	898.9	715.5	725.4	786.4	818.8	867.6
Global Precipitation Measurement (GPM)	74.4	157.8	159.5	127.6	137.5	111.2	80.4
Glory Mission	82.3	50.7	27.1	10.1	4.4	1.9	0.0
Landsat Data Continuity Mission (LDCM)	127.3	200.9	120.6	137.4	165.0	90.0	15.0
NPOESS Preparatory Project (NPP)	46.1	57.1	112.8	33.8	5.3	5.2	5.1
Ice, Cloud, and land Elevation Satellite (ICESat-II)	9.6	38.8	39.2	74.6	99.1	126.9	161.7
Soil Moisture Active and Passive (SMAP)	9.6	104.3	70.0	132.2	180.4	135.0	40.0
Decadal Survey Missions	16.8	82.3	0.0	10.9	8.8	161.1	374.6
Other Missions and Data Analysis	180.1	206.9	186.3	198.9	186.0	187.5	190.8
FY 2009 President's Budget Request	530.1	677.9	661.5	583.2	563.6	569.6	--
Global Precipitation Measurement (GPM)	74.4	125.8	161.7	129.8	140.0	113.3	--
Glory Mission	35.2	29.7	9.1	9.8	2.7	0.0	--
Landsat Data Continuity Mission (LDCM)	133.0	139.4	127.1	96.0	11.3	2.7	--
NPOESS Preparatory Project (NPP)	70.0	94.4	46.3	8.6	8.9	9.2	--
Decadal Survey Missions	33.0	103.2	116.2	150.0	250.2	290.7	--
Other Missions and Data Analysis	184.6	185.4	201.1	188.9	150.5	153.7	--
Changes from FY 2009 Request	16.0	221.0	54.0	142.3	222.8	249.2	--

Note: Includes $200.3M in Recovery Act funding in FY09

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Program Overview

The Earth Systematic Missions (ESM) Program provides a number of Earth-observing satellites that contribute to the provision of long-term environmental data sets that can be used to study the evolution of the Earth system on a range of temporal scales. This information is used to analyze, model, and improve understanding of the Earth system. Data gathered by these spacecraft will enable improved predictions of climate, weather, and natural hazards. NASA works with the science community to identify science questions on the frontiers of science that have profound societal importance, and to which on-going remote sensing of the Earth can make a defining contribution. These science questions become the foundation of a research strategy, which defines requirements for scientific observations through the vantage point of space. Each of Earth Science's six focus areas has an implementation roadmap that shows what role space-based observations play in meeting overall science objectives. The six Earth Science focus areas are as follows: (1) Climate variability and change; (2) Atmospheric composition; (3) Carbon cycle, ecosystems, and biogeochemistry; (4) Water and energy cycles; (5) Weather; and (6) Earth surface and interior. This effort also provides techniques and technologies that can be employed to predict climate, weather and natural hazards on planets we plan to explore.

For more information, see http://science.hq.nasa.gov/missions/earth.html.

Plans For FY 2010

As a result of the funding provided by the American Recovery and Reinvestment Act of 2009, and a significant commitment by the new Administration to Earth Science in FY 2010-14, significant progress can be made towards the goals identified in the National Research Council (NRC) 2007 report, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond". The Soil Moisture Active-Passive (SMAP) and Ice, Cloud, and Land Elevation Satellite (ICESat II) missions will be pursued aggressively, leading to projected launches in late 2013/early 2014 and late 2014/early 2015 respectively. Studies of the next two Decadal Survey missions, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI), will also intensify.

Also in response to the NRC report, NASA is initiating a new series of competed "Venture-class" missions. These missions, which may include suborbital payloads, instruments to be flown on non-NASA spacecraft, or small dedicated spacecraft, will be selected via an Announcement of Opportunity. Selection of the first Venture-class mission(s) is planned for FY 2010.

NASA has also begun development of the Thermal Infrared Sensor (TIRS) instrument, which is now fully funded within the LDCM Project.

The following other activities will be undertaken in FY 2010:

- GPM will complete its Preliminary Design Review followed by Confirmation Review and KDP-C,
- NPP will complete its satellite pre-environmental review,
- Glory will have its Launch Readiness Review, followed by the launch of the spacecraft, and
- LDCM will complete its instrument Critical Design Review and Mission Critical Design Review.

Nine of the ten operating spacecraft in the Earth Systematic Mission program were reviewed in 2007 as part of the biennial Senior Review. (Aura is still in its prime mission phase and was not reviewed. The EP/TOMS mission was decommissioned in early 2007 and was not a part of the Senior Review.) All nine missions were extended for the FY 2008 - FY 2009 period, with some modifications to their mission implementation plans. All missions including Aura will be a part of the 2009 Senior Review.

Project Descriptions and Explanation of Changes

Global Precipitation Measurement (GPM) Mission

Extending precipitation measurements beyond the current Tropical Rainfall Measuring Mission (TRMM), GPM will provide: near-global measurements of precipitation, its distribution, and physical processes; rain rates and latent heating measurement; and more frequent and complete sampling of Earth's precipitation. The science focus areas served by GPM will include: climate variability and change; water and energy cycles; and weather. Additional GPM information is available under the Development section.

Glory Mission

Glory will provide measurements of global distribution of natural and anthropogenic aerosols from varying angles, in numerous spectral bands with multiple polarizations, as well as total solar irradiance measurements. The science focus areas served by Glory will include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; and water and energy cycles. Additional Glory information is available under the Development section.

Landsat Data Continuity Mission (LDCM)

Landsat Data Continuity Mission (LDCM) will provide visible and near-infrared images of the Earth surface in approximately nine frequency bands, with 30-meter resolution. LDCM will enable cross-sensor comparison of data from within the Landsat series. The science focus areas served by LDCM will include: carbon cycle, ecosystems, and biogeochemistry; and earth surface and interior. LDCM is being undertaken by NASA as a stand-alone "free-flyer" mission, planned for launch as soon as possible to provide continuity of Landsat data. Additional LDCM information is available under the Development section.

NPOESS Preparatory Project (NPP)

NPP is a preparatory mission for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) and will provide global imagery in a number of visible and infrared frequency bands, collect ozone data, and provide improved measurements of temperature and moisture profiles in the atmosphere. The science focus areas served by NPP will include: atmospheric composition; climate variability and change; carbon cycle, ecosystems, and biogeochemistry; water and energy cycles; and weather. Additional NPP information is available under the Development section.

Ice, Cloud, and land Elevation Satellite (ICESat-II)

ICESat-II, currently in formulation, is the planned follow-on mission to ICESAT. Additional ICESat-II information is available under the Formulation section.

Soil Moisture Active and Passive (SMAP)

The Soil Moisture Active and Passive (SMAP) mission will provide new information on global soil moisture and its freeze/thaw state enabling new advances in hydrospheric science and applications. Direct measurements of soil moisture and freeze/thaw state are needed to improve understanding of regional and global water cycles, terrestrial ecosystems, and the processes that link the water, energy, and carbon cycles. Soil moisture and freeze/thaw information provided by SMAP will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon. Additional SMAP information is available under the Formulation section.

Decadal Survey Missions

This project supports missions that begin formulation in the near future to implement systematic measurements in response to Tier 1 and Tier 2 priorities suggested by the National Research Council's Earth Science Decadal Survey.

Other Missions and Data Analysis

Ocean Surface Topography Mission (OSTM) - OSTM was launched June 20, 2008. The satellite measures sea surface height to an accuracy of less than four centimeters every 10 days. The science focus areas served by OSTM will include: climate variability and change; and water and energy cycles. This mission is a follow-on to Jason, and is currently in its prime phase through June 2011.

Terra - Terra collects global data on the state of the atmosphere, land, and oceans, as well as their interactions with solar radiation and with one another. The science focus areas served by Terra include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; earth surface and interior; water and energy cycles; and weather. Terra is a joint mission with Japan and Canada.

Aqua - Aqua monitors atmospheric, land, ocean, and ice variables for improved understanding of the Earth's water cycle and improved understanding of the intricacies of the climate system. The science focus areas served by Aqua include: atmospheric composition; carbon cycle, ecosystems, and biogeochemistry; climate variability and change; water and energy cycles; and weather. Aqua is a joint mission with Brazil and Japan.

Aura - Aura measures atmospheric chemical composition, tropospheric/stratospheric exchange of energy and chemicals, chemistry-climate interactions, and air quality. The science focus areas served by Aura include: atmospheric composition; climate variability and change; and weather. Aura is a joint mission with the Netherlands, Finland, and the United Kingdom.

Tropical Rainfall Measuring Mission (TRMM) - TRMM measures precipitation, clouds, lightning, and radiation processes over tropical regions. TRMM is one of several spacecraft currently extending the long-term radiation budget record begun in the mid-1980s. The science focus areas served by TRMM include: climate variability and change; water and energy cycles; and weather. TRMM is a joint mission with Japan.

Other Missions and Data Analysis (continued)

Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat) - ACRIMSat monitors total solar irradiance. The science focus areas served by ACRIMSat include: climate variability and change; and water and energy cycles. Because ACRIMSAT has continued to operate beyond its original planned base mission, it now provides similar measurements to its operating follow-on mission, SORCE.

Quick Scatterometer (QuickSCAT) - QuickSCAT measures ocean surface wind vectors using the SeaWinds instrument. The science focus areas served by QuikSCAT include: climate variability and change; and weather.

Earth Observing-1 (EO-1) - The EO-1 spacecraft collects data to allow paired scene comparisons between the EO-1 Advanced Land Imager (ALI) and the Landsat-7 Enhanced Thematic Mapper Plus (ETM+). The science focus areas served by EO-1 include: carbon cycle, ecosystems, and biogeochemistry; and earth surface and interior.

Ice, Clouds, and Land Elevation Satellite (ICESat) - ICESat measures elements of ice-sheet mass balance, cloud-top and land-surface topography, and vertical profiles of aerosol and cloud properties. The science focus areas served by ICESat include: climate variability and change; earth surface and interior; and water and energy cycles.

Jason - Jason monitors ocean height to support the study of ocean circulation. The science focus areas served by Jason include: climate variability and change; and water and energy cycles. Jason is a joint mission with France.

Solar Radiation and Climate Experiment (SORCE) - SORCE measures the total and spectral solar irradiance incident at the top of Earth's atmosphere. The science focus areas served by SORCE include: atmospheric composition; climate variability and change; and water and energy cycles.

Instrument Science Teams - Instrument science teams help define the scientific requirements for their respective instruments and generate the algorithms used to process the data into useful data products for the investigations. Additionally, the science teams are responsible for validating their own algorithms and data products. The Earth Systematic Missions Program is supported by the Precipitation Science Team, the Ocean Winds Science Team, and the Landsat Science Project Office.

Earth Systematic Missions Senior Review Competed Science - NASA's Earth Science Division uses Senior Reviews, which are held every two years, to assess the relative science value of missions in operation. These reviews are competitive in nature and serve as the basis for determining whether a mission which has completed its current approved phase should be extended.

Earth Science Program Management - Provides program management support for Earth Science missions, investigations, and activities. Additionally, provides funding for the Earth Systematic Missions (ESM) Program Office and the Earth System Science Pathfinder (ESSP) Program Office, which assist in the overall management and execution of the Earth Science formulation, development, and operating missions.

Earth Observation Systems (EOS) Research - The EOS research project funds science for the EOS missions, currently Terra, Aqua, Aura, ICESAT I and Land Cover missions. These individual-investigator, competitively selected research projects analyze data from the missions to address the related science questions, especially focussed on the earth's polar regions. Some funded projects continue algorithm improvement and validation for the EOS Instruments data products, while overall the selected activities focus on science data analyses and the development of Earth System Data Records (ESDRs), including Climate Data Records (CDRs) relevant to NASA's research program. Studies using ICESat I and CryoSat-2 are solicited in the ROSES 2009 sub-element. CryoSat-2 is a European Space Agency satellite that is due to be launched in 2009 and will be operating in the observational gap between ICESat I and ICESat II.

Earth Systematic Missions (ESM) Research - The ESM research project funds science teams for the Earth Systematic missions, currently NPP and Glory missions. These are individual investigator competitively selected research to analyze data from the missions to address the related science questions. In particular, the NPP science investigations are focused on developing climate data records from EOS observations continued by the NPOESS operational observing system. The first science for the Glory mission is solicited in ROSES 2009 sub-element.

Ocean Vector Winds Science Team (OVWST) - This project utilizes scientific data received from the QuikSCAT (Quick Scatterometer) Mission satellite which measures ocean surface wind vectors by sensing ripples caused by winds near the ocean's surface, from which scientists can compute the winds' speed and direction, acquiring hundreds of times more observations of surface wind velocity each day than can ships and buoys. Previously this project was associated with the Earth Systematic Mission area wherein the QuikSCAT mission is managed. Beginning in fiscal year 2010, the Ocean Vector Winds Science Team moves into the Research Program to better align competed science research activities.

Ocean Surface Topography Science Team (OSTST) - This project utilizes scientific data received from the Ocean Surface Topography Mission (OSTM) satellite which measures global sea surface height. Previously this project was associated with the Earth Systematic Mission area wherein the OSTM mission is managed. Beginning in fiscal year 2010, the Ocean Surface Topography Science Team moves into the Research Program to better align competed science research activities.

Precipitation Science Team - This project utilizes scientific data received from the Tropical Rainfall Measuring Mission (TRMM) satellite to improve the forecasting of weather and severe storm events. Previously this project was associated with the Earth Systematic Mission area wherein the TRMM is managed. Beginning in fiscal year 2010, the Precipitation Science Team moves into the Research Program to better align competed science research activities.

Program Commitments

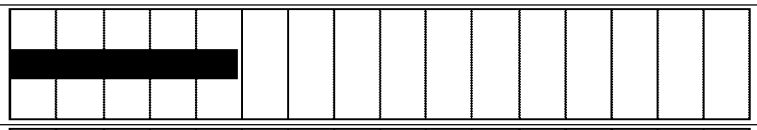
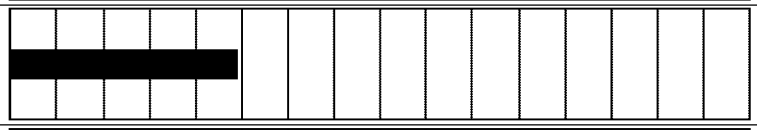
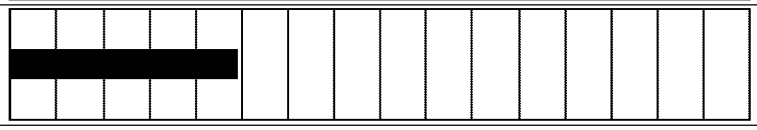
Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Complete planned operations of currently operating missions.	Operating missions	Same
Data collection.	EO-1	Same
Launch 2 additional Earth Systematic Mission (ESM) missions.	Glory	Glory launch is now in 2010 and NPP launch is now in 2011.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22		Beg	End
Global Precipitation Measurement Mission (GPM)																	Tech Form Dev Ops Res	Jul-02 Nov-08 Jul-13	Oct-08 Jun-13 Jul-16
Glory																	Tech Form Dev Ops Res	Oct-03 Nov-05 Jan-10	Nov-05 Jan-10 Mar-12
Landsat Data Continuity Mission (LDCM)																	Tech Form Dev Ops Res	Oct-03 Mar-07 Dec-12	Feb-05 Nov-12 Jul-17
SMAP																	Tech Form Dev Ops Res	Sep-08 Apr-10 Oct-13	Apr-10 Sep-13 Mar-16
ICESat-II																	Tech Form Dev Ops Res	Jun-09 Aug-12 Oct-14	Aug-12 Sep-14 Dec-18
Ocean Surface Topography Mission (OSTM)																	Tech Form Dev Ops Res	Dec-02 Mar-06 Jul-08	Mar-06 Jun-08 Jul-11
NPOESS Preparatory Project (NPP)																	Tech Form Dev Ops Res	Mar-00 Dec-03 Jan-11	Nov-03 Jan-11 Jan-16
Terra																	Tech Form Dev Ops Res	 Oct-99	 Sep-11 Sep-11
Aqua																	Tech Form Dev Ops Res	 May-02	 Sep-11 Sep-11
Aura																	Tech Form Dev Ops Res	 Jul-04	 Jul-10 Jul-12
Tropical Rainfall Measuring Mission (TRMM)																	Tech Form Dev Ops Res	 Nov-97	 Sep-11 Sep-11
Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat)																	Tech Form Dev Ops Res	 Dec-99	 Sep-09 Sep-11
Quick Scatterometer (QuikSCAT)																	Tech Form Dev Ops Res	 Jun-99	 Sep-11 Sep-11

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Earth Observing-1 (EO-1)		Tech Form Dev Ops Res	Nov-00	Sep-11
Jason		Tech Form Dev Ops Res	Dec-01	Sep-11
Ice, Clouds, and Land Elevation Satellite (ICESat)		Tech Form Dev Ops Res	Jan-03	Sep-11 Sep-11
Solar Radiation and Climate Experiment (SORCE)		Tech Form Dev Ops Res	Jan-03	Sep-11

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

Program Management

GSFC manages NPP, LDCM, Glory, GPM, Terra, Aqua, Aura, TRMM, EO-1, SORCE, ICESat, and ICESat-II. JPL manages OSTM, ACRIMSat, SMAP, QuikSCAT, and Jason.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
GPM	GSFC	GSFC	JAXA - provides the dual frequency precipitation radar and a launch vehicle for GPM.
Glory	GSFC	GSFC	None.
LDCM	GSFC	GSFC	USGS - provides data processing/distribution and on-orbit operations for LDCM.
ICESat-II	GSFC	GSFC	TBD
SMAP	JPL	JPL/GSFC	TBD
OSTM	JPL	JPL	CNES - provides spacecraft, 2 core instruments, and data processing for OSTM. NOAA provides data processing/distribution, ground stations, and on-orbit operations. EUMETSAT provides a ground station and data processing/distribution.
NPP	GSFC	GSFC	NOAA/IPO - provides 3 of 4 instruments and ground system for NPP.
Terra	GSFC	GSFC	Japan's Ministry of Economy, Trade and Industry (METI) provided the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The Canadian Space Agency provided the Measurements of Pollution in The Troposphere (MOPITT) instrument.
Aqua	GSFC	GSFC	The National Space Development Agency (NASDA, now part of the Japan Aerospace Exploration Agency, or JAXA) provided the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) instrument. Brazil's Instituto Nacional de Pesquisas Espaciais (INPE, the Brazilian Institute for Space Research) provided the Humidity Sounder for Brazil (HSB) instrument.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aura	GSFC	GSFC	The National Environmental Research Council of the United Kingdom funded the High Resolution Dynamics Limb Sounder (HIRDLS); the instrument was designed by universities and laboratories in the U.K. and the U.S., including the University of Colorado, Oxford University, the National Center for Atmospheric Research (U.S.), and the Rutherford Appleton Laboratory (U.K.). The University of Edinburgh (U.K.) contributed to data processing algorithms and validation for the Microwave Limb Sounder (MLS). The Ozone Monitoring Instrument (OMI) was built by Dutch Space and TNO TPD in the Netherlands in cooperation with Finnish VTT and Patria Advanced Solutions Ltd. KNMI (Royal Netherlands Meteorological Institute) is the Principal Investigator Institute. Overall responsibility for OMI lies with the Netherlands Agency for Aerospace Programmes (NIVR), with the participation of the Finnish Meteorological Institute (FMI).
TRMM	GSFC	GSFC	The Japan Aerospace Exploration Agency (JAXA) provided the Precipitation Radar (PR) instrument and the launch vehicle (an H-II F6).
ACRIMSat	JPL	JPL	None.
QuikSCAT	JPL	JPL	None.
EO-1	GSFC	GSFC	None.
Jason	JPL	JPL	The French Centre National d'Etudes Spatiales (CNES, the National Center for Space Studies) is responsible for the Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) instrument; THALES built the instrument, and SMP provided the ground beacons. The CNES is also responsible for the Poseidon-2 nadir-viewing radar altimeter; Alcatel Space Industries was prime contractor for the instrument.
ICESat	GSFC	GSFC	None.
SORCE	GSFC	GSFC	None.

Acquisition Strategy

The LDCM instrument was selected through open competition in FY 2007. The Ball Aerospace and Technologies Corporation will build the Operational Land Imaging (OLI) instrument for LDCM. LDCM spacecraft used Rapid Spacecraft Development Office selection, and selected General Dynamics.

NPOESS Preparatory Project (NPP): Spacecraft, ATMS, and CERES were procured competitively. The VIIRS, OMPS, and CrIS were procured competitively via the NPOESS Integrated Program Office. The procurement award for each element was as follows:

Ball Aerospace: Spacecraft and Ozone Mapping Profile Suite Development
NG Electronic Systems: Advanced Technology Microwave Sounder Development
ITT Aerospace: Cross-track Infrared Sounder Development
Raytheon: Visible Infrared Imaging Radiometer Development
NG Space Technology: Clouds and the Earth's Radiant Energy System Development
Raytheon: Ground systems and operations.

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation will build the GPM Microwave Imager (GMI) instrument for GPM. The GPM Core Spacecraft will be an in-house development at GSFC. The Dual-frequency Precipitation Radar (DPR) instrument and launch vehicle for the Core Spacecraft will be provided by a foreign partner, Japan Aerospace Exploration Agency (JAXA). The Constellation Spacecraft will be acquired by open competition through the GSFC Rapid Spacecraft Development Office. Its launch vehicle will be acquired via competitive process by Kennedy Space Center. The ground systems for both spacecraft will be selected through open competition.

Senior Reviews are held every two years to assess the relative science value of missions in operation. In FY 2007, all operating Earth Systematic Missions other than Aura went through the competitive Senior Review process to determine whether they should enter an extended mission phase after their current missions have been completed. Preparations are underway for the 2009 Senior Reviews in which 13 operating missions will be evaluated.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	4/2007	2007 Senior Review- All operating Earth Sytematic Missions except for Aura underwent this review. All missions were extended with modifications to their mission budgets.	04/2009

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**218.5**	**82.3**	**50.7**	**27.1**	**10.1**	**4.4**	**1.9**	**0.0**	**0.0**	**395.0**
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.8
Development / Implementation	147.7	82.3	50.7	15.4	0.0	0.0	0.0	0.0	0.0	296.1
Operations / Close-out	0.0	0.0	0.0	11.7	10.1	4.4	1.9	0.0	0.0	28.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**219.2**	**35.2**	**29.7**	**9.1**	**9.8**	**2.7**	**0.0**	**--**	**0.0**	**305.7**
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	70.8
Development / Implementation	148.4	35.2	25.1	0.0	0.0	0.0	0.0	--	0.0	208.7
Operations / Close-out	0.0	0.0	4.6	9.1	9.8	2.7	0.0	--	0.0	26.2
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	**-0.8**	**47.1**	**21.0**	**18.0**	**0.3**	**1.7**	**1.9**	**--**	**0.0**	**89.2**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Development / Implementation	-0.7	47.1	25.6	15.4	0.0	0.0	0.0	--	0.0	87.4
Operations / Close-out	0.0	0.0	-4.6	2.6	0.3	1.7	1.9	--	0.0	1.9
Other	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.1

Explanation of Project Changes

Cost growth since the FY 2009 Budget is related to the launch delay from March 2009 to January 2010. The reasons for the launch delay, and associated cost growth, were addressed in NASA's Glory Project Cost and Schedule Analysis Report (CSAR) to Congress, as required by Section 103(d)(2) of the NASA Authorization Act of 2005.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Project Purpose

The Glory mission will contribute to NASA's research regarding the atmospheric conditions that influence climate and improve understanding of the natural and man-made factors that contribute to climate change. It will also enable a greater understanding of the seasonal variability of aerosol properties. Both advances are essential components of predicting climate change. Solar radiation is the dominant, direct energy input into the terrestrial ecosystem, affecting all physical, chemical, and biological processes. Aerosols interact with atmospheric conditions in complex ways that can have large effects on climate.

Glory's science objectives are to:
* Determine the global distribution, microphysical properties, and chemical composition of natural and anthropogenic aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the aerosol direct and indirect effects on climate.
* Continue measurement of the total solar irradiance to determine the Sun's direct and indirect effect on Earth's climate.

For more on the scientific questions addressed by Glory, visit http://glory.gsfc.nasa.gov/.

Project Parameters

The Glory mission will operate two scientific instruments aboard a preexisting NASA spacecraft asset requiring minor modification. The Glory satellite will fly in NASA's low Earth orbit Afternoon, or A-Train, constellation to enhance the utility of the mission data through synergistic observations and measurements from the other satellites. The A-Train constellation currently includes five spacecraft flying in close temporal proximity to each other, providing detailed observations of the Earth system. The Glory spacecraft will be the seventh satellite in the A-Train when it joins the constellation in 2009.

The Aerosol Polarimetry Sensor is an advanced polarimeter which will provide measurements that increase our understanding of black carbon soot and other aerosols as causes of climate change. The APS will provide unprecedented measurements of the global distribution of natural and anthropogenic aerosols and clouds with accuracy and coverage sufficient for a reliable quantification of the aerosol direct and indirect effects on climate. The APS is being developed by Raytheon Space and Airborne Systems, El Segundo, California.

The Total Irradiance Monitor (TIM) instrument provides measurement continuity for the 28-year solar irradiance data record by extending the measurement currently provided by NASA's Solar Radiation and Climate Experiment (SORCE). University of Colorado's Laboratory for Atmospheric and Space Physics is developing the TIM sensor, the instrument's Sun pointing platform, and the TIM science operations center.

Orbital Science Corporation, Dulles, Virginia, is developing the spacecraft and the ground system/mission operations center, and will integrate the instruments. Orbital also provides mission systems engineering support and performs mission operations.

Kennedy Space Center is responsible for Glory launch services. The mission will launch on a Taurus XL from Vandenberg Air Force Base, California.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Project Commitments

Glory will launch in January 2010 to begin a three-year prime mission (with a five-year goal) to gather scientific measurements of atmospheric aerosols and solar irradiance.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Aerosol Polarimetry Sensor (APS)	Raytheon	Provide unprecedented measurements of the global distribution of natural and anthropogenic aerosols	Same	Same
Total Irradiance Monitor (TIM)	U of Colorado LASP	Maintain an uninterrupted solar irradiance data record	Same	Same
Spacecraft	Orbital	Refurbishment of the Vegetation Canopy Lidar (VCL) mission bus	Same	Same
Launch vehicle	Orbital	Taurus XL	Same	Same
Ground System Ops, TIM Science Ops, APS Science Ops	Orbital / Colorado University-Boulder LASP /GSFC Institute for Space Studies	Combination of the commercial ground stations and the networks that connect them	Same	Full APS sci. data process. 1 yr, data archival remaining 2 yrs, full TIM sci. data process. 3 yrs
Mission Ops	Orbital	Operations of the spacecraft and the generation of command uplink	Same	Same
Data Archive	GSFC Earth Science Distributed Active Archive Center (GES DAAC)	Archival and distribution of mission data	Same	Same

Schedule Commitments

Glory was confirmed for development on December 13, 2005.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
Mission Confirmation Review	11/2005	12/2005	12/2005
Mission Pre-ship review	8/2008	1/2009	1/2009
Launch	12/2008	3/2009	1/2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Development Cost and Schedule Summary

The base year development cost estimate below is consistent with the revised baseline reported in the Glory Project Cost and Schedule Analysis Report (CSAR) to Congress. At that time, the launch date was estimated to be June 2009. Cost growth since that time is due to the additional delay until November 2009. The Project is making good progress towards the new launch date.

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Glory Mission	2008	259.1	2009	296.1	14	Launch Readiness	6/15/2009	1/23/2010	7

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**259.1**	**296.1**	**37.0**
Aircraft/Spacecraft	31.7	37.5	5.8
Payloads	117.4	138.6	21.2
Systems I&T	3.2	3.8	0.6
Launch Vehicle/Services	55.4	55.4	0.0
Ground Systems	0.9	1.1	0.2
Science/Technology	10.3	12.2	1.9
Other Direct Project Cost	40.2	47.5	7.3

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	Glory Mission

Project Management

Goddard Space Flight Center has Project Management responsibility. The Science Mission Directorate Program Management Council has program oversight responsibility.

The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
APS	GSFC	GSFC	None
TIM	GSFC	GSFC	None

Acquisition Strategy

All major procurements for the directed Glory Mission were sole-source awarded to meet the objective for an accelerated mission.

Aerosol Polarimetry Sensor: Raytheon Space and Airborne Systems.
Total Irradiance Monitor: University of Colorado Laboratory for Atmospheric and Space Physics.
Spacecraft/spacecraft support: Orbital Science Corporation.

There are no remaining major procurements, as all instrument and spacecraft contracts are in place.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NASA HQ	04/2008	DPMC Mission Continuation Review - Directorate review of Project replan (incl. corrective actions, risk mitigations, revised cost estimates). Replan approved May 2008, changing LRD from 12/2008 to 6/2009 (LRD will now be later then 6/2009). 6/2009 is the Flight Operations Review.	06/2009

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
APS Instrument	Instrument contractor poor performance will cause increased cost and possible impact to launch readiness date.	HQ and GSFC implementing DPMC replan of April 2008. The project is monitoring contractor performance trends, and assisting the instrument provider with technical, planning, and management expertise.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**542.9**	**46.1**	**57.1**	**112.8**	**33.8**	**5.3**	**5.2**	**5.1**	**6.0**	**814.3**
Formulation	47.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.7
Development / Implementation	495.2	46.1	57.1	112.8	28.8	0.0	0.0	0.0	0.0	740.0
Operations / Close-out	0.0	0.0	0.0	0.0	5.0	5.3	5.2	5.1	6.0	26.6
Other	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**554.5**	**70.0**	**94.4**	**46.3**	**8.6**	**8.9**	**9.2**	**--**	**11.4**	**803.3**
Formulation	47.7	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	47.7
Development / Implementation	506.8	70.0	94.4	46.3	0.0	0.0	0.0	--	0.0	717.5
Operations / Close-out	0.0	0.0	0.0	0.0	8.6	8.9	9.2	--	11.4	38.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	**-11.6**	**-23.9**	**-37.3**	**66.5**	**25.2**	**-3.6**	**-4.0**	**--**	**-5.5**	**11.0**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	-11.6	-23.9	-37.3	66.5	28.8	0.0	0.0	--	0.0	22.5
Operations / Close-out	0.0	0.0	0.0	0.0	-3.6	-3.6	-4.0	--	-5.4	-11.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	-0.1	0.0

Note: The FY 2010 LCC number in the table above is overstated by $14.9M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of the initial operating plan, the estimated NPP lifecycle cost will be $799.4M, and the estimated Development cost will be $725.1M.

Explanation of Project Changes

The changes to the NPP budget are due to the launch delay from June 2010 until January 2011, primarily caused by late delivery of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Purpose

The NPOESS Preparatory Project (NPP) is a joint mission with National Oceanic and Atmospheric Administration and the U.S. Air Force to extend key environmental measurements. The satellite will provide atmospheric and sea surface temperatures, humidity sounding, land and ocean biological productivity, cloud and aerosol properties, and earth radiation budget measurements.

The NPP mission has two objectives: Provide a continuation of global change observations following the Earth Observing System missions Terra and Aqua, and provide the National Polar-orbiting Operational Environmental Satellite System (NPOESS) with risk-reduction demonstration and validation for the critical NPOESS sensors, algorithms, and ground processing.

For more information, visit the following website: http://jointmission.gsfc.nasa.gov

Project Parameters

The NPP spacecraft is based on a modified Ball Commercial Platform 2000 bus with a five-year design life. The NPP orbit is a polar, Sun-synchronous orbit at a nominal altitude of 824 kilometers. Four of the instruments are newly developed sensors based on heritage NASA sensors. The Advanced Technology Microwave Sounder (ATMS) is being developed by NASA, and three of the instruments (Visible/Infrared Imaging Radiometer Suite (VIIRS), Cross-track Infrared Sounder (CrIS), and Ozone Mapping and Profiling Suite (OMPS)) are being developed by the NPOESS Integrated Program Office (IPO). A fifth sensor, the Clouds and the Earth's Radiant Energy System (CERES) was a spare sensor developed by NASA for the Earth Observing System (EOS) program.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Commitments

NPP will launch in January 2011 and undertake the following scientific measurements over its five-year operating life: atmospheric and sea surface temperatures, humidity soundings, land and ocean biological productivity, cloud and aerosol properties, and Earth radiation budget measurements.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Visible Infrared Imaging Radiometer Suite (VIIRS)	Raytheon SBRS	Provide global imagery in visible and infrared frequency bands: 0.3 to 14 microns / 400 m resolution.	Same	Same
Ozone Mapping and Profiler Suite (OMPS)	Ball Aerospace	Collection of total column and vertical profile ozone data with 300-380 nm / LIMB 290-1000 nm .	Same	Same
Cross-Track Infrared Sounder (CrIS)	ITT Aerospace	Temperature and moisture profiles at 3.9-15.4 microns.	Same	Same
Advanced Technology Microwave Sounder (ATMS)	NG Electronic Systems	Temperature and moisture profiles at 22 channels / 23-183 ghz.	Same	Same
Clouds and the Earth's Radiant Energy System (CERES)	NG Space Technology	Provide Earth radiation budget measurements in shortwave (0.3-5micron) and longwave (8-12 micron) bands		New
Spacecraft	Ball Aerospace	5-year design life, mass is 2228 kg, Power 1400 watts.	Same	Same
Launch vehicle	Boeing	Delta II 7920.	Same	Same
Ground system	Raytheon	Command, Control, and Communication Segment (C3S) and Interface Data Processing Segment (IDPS).	Same	Same

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Schedule Commitments

The NPP mission completed Mission Confirmation Review (MCR) in November 2003.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
CrIS Flight Model Delivery	Oct 2005	May 2008	May 2008
ATMS Flight Model Delivery	Apr 2005	Oct 2005	Oct 2005
OMPS Flight Model Delivery	Sep 2005	Aug 2008	Aug 2008
VIIRS Flight Model Delivery	Nov 2005	Apr 2009	Nov 2009
CERES Flight Model Delivery	N/A	N/A	Oct 2008
Operations Readiness Review	Jun 2006	Dec 2009	Dec 2009
Launch	Oct 2006	Jun 2010	Jan 2011

Development Cost and Schedule Summary

The VIIRS sensor delivery from NASA's NPOESS partners continues to impact the NPP project. Ongoing issues with the VIIRS sensor development has caused the NPP launch to slip again. The revised NPP launch date is now January 2011 due to the late sensor delivery.

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
NPOESS Preparatory Project (NPP)	2006	592.9	2008	725.1	22	Launch Readiness	4/30/2008	1/31/2011	33

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**592.9**	**725.1**	**132.2**
Aircraft/Spacecraft	160.0	164.3	4.3
Payloads	194.2	162.3	-31.9
Launch Vehicle/Services	72.9	93.3	20.4
Ground Systems	48.2	49.4	1.2
Other Direct Project Cost	117.6	224.3	106.7
Science/Technology	0.0	31.5	31.5

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Management

GSFC is responsible for NPP project management. Agency PMC has program oversight responsibility. NOAA/DOD IPO is responsible for managing development of OMPS, CrIS and VIIRS instruments. Responsible official is the Earth Science Division Director.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	None	None
ATMS Development	GSFC	None	None
OMPS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
CrIS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
VIIRS Development	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)
CERES Refurbishment	GSFC	LaRC	NOAA
Data archive and storage	GSFC	None	NOAA
Ground Systems and Ops	NPOESS-IPO	None	NOAA / DoD (NPOESS-IPO)

Acquisition Strategy

Spacecraft, ATMS, and CERES were procured competitively. The VIIRS, OMPS, and CrIS were procured competitively via the NPOESS Integrated Program Office.

The procurement award for each element was as follows:
Ball Aerospace: Spacecraft and OMPS Development;
NG Electronic Systems: ATMS Development;
ITT Aerospace: Crls Development;
Raytheon: VIIRS Development;
NG Space Technology: CERES; and
Raytheon: Ground systems and operations.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	NPP IRT	10/2008	Mission Operations Review/Successfully completed.	N/A
Performance	NPP IRT	N/A	Operations Readiness Review	12/2009

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	NPOESS Preparatory Project (NPP)

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Instrument Delivery Delay	Government has taken a hands-on approach to the day -to-day management of VIIRS. The program has installed a Government Program Manager (GPM) at Raytheon to provide oversight and timely decisions. The GPM is an experienced NASA instrument manager.	NASA and NPOESS-IPO team working together to identify further work-arounds to minimize impacts.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Global Precipitation Measurement (GPM)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	74.4	157.8	159.5	127.6	137.5	111.2	80.4
FY 2009 President's Budget Request	74.4	125.8	161.7	129.8	140.0	113.3	--
Total Change from 2009 President's Budget Request	0.0	32.0	-2.2	-2.2	-2.5	-2.1	--

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Global Precipitation Measurement (GPM)

Project Purpose

The Global Precipitation Measurement (GPM) mission will advance the measurement of global precipitation, making possible high spatial resolution precipitation measurements available at a three-hour or less refresh rate over much of the globe. A joint mission with the Japan Aerospace Exploration Agency (JAXA), GPM will provide the first opportunity to calibrate measurements of global precipitation (including the distribution, amount, rate, and associated heat released) across tropic, mid-latitude, and polar regions.

The GPM mission has the following scientific objectives:

(1) Advance precipitation measurement capability from space through combined use of active and passive remote-sensing techniques. These advanced measurements will be used to calibrate dedicated and operational passive microwave sensors with the goal of achieving global sampling.
(2) Advance understanding of global water/energy cycle variability and fresh water availability. Improved measurements of the space-time variability of global precipitation will substantially close the water/energy budget and elucidate the interactions between precipitation and other climate parameters.
(3) Improve climate prediction by providing the foundation for better understanding of surface water fluxes, soil moisture storage, cloud/precipitation microphysics and latent heat release in the Earth's atmosphere.
(4) Advance Numerical Weather Prediction (NWP) skills through more accurate and frequent measurements of instantaneous rain rates with better error characterizations, and the development of improved assimilation methods.
(5) Improve flood-hazard and fresh-water-resource prediction capabilities through better temporal sampling and wider spatial coverage of high-resolution precipitation measurements, and innovative designs in hydro-meteorological modeling.

For more information see http://science.hq.nasa.gov/missions/earth.html.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Global Precipitation Measurement (GPM)

Project Preliminary Parameters

The GPM Project includes a Core Observatory Spacecraft and the Low-Inclination Observatory Spacecraft. The Core Observatory will leverage passive microwave measurements from other operating and planned "satellites of opportunity" by calibrating their measurements to its own. The exact sampling rate over different areas of the globe will depend on the number and orbits of the satellites of opportunity, but given the prevalence of passive microwave instruments on operational satellite systems, the global sampling will be robust.

The NASA Core Observatory will fly in a 65 degree inclined orbit at an altitude of 407 kilometers; the 65 degree orbit provides improved latitude coverage over TRMM (which is 35 degrees). The Core Observatory includes two scientific instruments which will provide active and passive microwave measurements of precipitation.

The JAXA-supplied Dual-frequency Precipitation Radar (DPR)instrument has cross-track swath widths of 245 km and 120 km, in Ku-band Ka-band, providing three-dimensional observation of rain and an accurate estimation of rainfall rate. The KuPR (13.6 GHz) subsystem of the DPR is an updated version of the highly successful radar flown on TRMM.

The GPM Microwave Imager (GMI)instrument is a conically-scanning radiometer which will provide significantly improved spatial resolution over the TRMM Microwave Imager (TMI).

The NASA Low-Inclination Observatory will fly in a 40 degree inclined orbit to improve real-time monitoring and prediction of hurricanes/typhoons; the satellites of opportunity will fly at multiple altitudes and inclinations.

The Core Observatory Spacecraft will be launched from Tanegashima Space Center, Japan on an H-IIA launch vehicle. NASA's Low-Inclination Observatory Spacecraft will be launched from Cape Canaveral Air Force Station on a Taurus-XL class launch vehicle. The DPR and GMI data will be relayed using the TDRSS multiple access (MA) and single access (SA) service.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Global Precipitation Measurement (GPM)

Estimated Project Deliverables

The GPM Core Observatory is planned for a launch in July 2013 to begin a three-year prime mission (five-year goal), followed by a launch in November 2014 of the NASA Low-Inclination Observatory, a passive microwave spacecraft. When calibrated with existing and planned passive microwave measurements, GPM will provide global measurements of precipitation with a sampling frequency of three hours or less over much of the globe.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Core Observatory	GSFC	Provides platform for the GMI and JAXA-supplied DPR instruments	Same	Same
Low-Inclination Observatory	GSFC	Provides platform for the second GMI instrument	Same	Same
Dual-frequency Precipitation Radar (DPR)	JAXA	Provides cross-track swath widths of 245 km and 120 km, for the Ku precipitation radar (KuPR) and Ka-band precipitation radar (KaPR).		Same
GPM Microwave Imager (GMI)	GSFC	Provides 13 microwave channels ranging in frequency from 10 GHz to 183 GHz; four high frequency, millimeter-wave, channels about 166 GHz and 183 GHz. 1.2 m diameter antenna	Same	Same
Launch Vehicle	JAXA	H-IIA	Same	Same

Estimated Project Schedule

GPM entered formulation in July 2002. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Development			
KDP-C	Dec 2003		May 2009
Core Observatory launch readiness date (LRD)	Nov 2010	Jun 2013	Jul 2013
Low-Inclination Observatory launch readiness date (LRD)		Jun 2014	Nov 2014

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Global Precipitation Measurement (GPM)

Project Management

Goddard Space Flight Center (GSFC) has project management responsibility. The Agency Program Management Council has program oversight responsibility.

The Earth Sciences Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Core Observatory	GSFC	GSFC	None
Core Observatory: GMI	GSFC	GSFC	None
Core Observatory: DPR	GSFC	GSFC	JAXA
Low-Inclination Observatory	GSFC	GSFC	To Be Determined
Low-Inclination Observatory: GMI	GSFC	GSFC	None
Launch vehicle and services: Core Observatory	GSFC	None	JAXA
Launch vehicle and services: Low-Inclination Observatory	GSFC	KSC	None

Acquisition Strategy

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation will build the GPM Microwave Imager (GMI) instrument for GPM. The GPM core spacecraft will be an in-house development at GSFC. The DPR instrument and launch vehicle for the Core Observatory will be provided by a foreign partner (JAXA). The Low-Inclination Observatory will be acquired by open competition through the GSFC Rapid Spacecraft Development Office (RSDO). Its launch vehicle will be acquired via competitive process by KSC. The ground systems for both spacecraft will be selected through open competition.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	IPAO	12/2005	Preliminary Design Review (PDR) was successful.	11/2008
Performance	IPAO	11/2008	Critical Design Review (CDR)	10/2009

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Non-NASA Constellation elements	Exact global sampling depends on operations of "spacecraft of opportunity" that are not part of this project.	NASA is developing data algorithms that allow GPM to make the broadest possible use of microwave instruments on other spacecraft; NASA participates in inter-agency and international planning processes for operational Earth observation measurements to maximize the leverage opportunities for GPM.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Landsat Data Continuity Mission (LDCM)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	127.3	200.9	120.6	137.4	165.0	90.0	15.0
FY 2009 President's Budget Request	133.0	139.4	127.1	96.0	11.3	2.7	--
Total Change from 2009 President's Budget Request	-5.7	61.6	-6.5	41.3	153.7	87.3	--

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Landsat Data Continuity Mission (LDCM)

Project Purpose

Unprecedented changes in land cover and use are having profound consequences for weather and climate change, ecosystem function and services, carbon cycling and sequestration, resource management, the national and global economy, human health, and society. The Landsat data series, begun in 1972, is the longest continuous record of changes in Earth's surface as seen from space and the only satellite system designed and operated to repeatedly observe the global land surface at moderate resolution. Landsat data are available at an affordable cost, providing a unique resource for people who work in agriculture, geology, forestry, regional planning, education, mapping, and global change research.

The purpose of the Landsat Data Continuity Mission (LDCM) is to extend the record of multi-spectral, moderate resolution Landsat-quality data, and to meet U.S. Government operational and scientific requirements for observing land use and land change.

For additional information, visit the LDCM Mission Home Page: http://ldcm.nasa.gov/

Project Preliminary Parameters

LDCM is being formulated for a Launch Readiness Date (LRD) that will minimize a potential data gap in the archive due to the fuel-limited life of Landsat-7. Recent analyses by the USGS and NASA have estimated the Landsat-7 mission should continue to operate through at least the end of 2012. The LDCM mission completed its Initial Confirmation Review, also known as the KDP-B transition review, on September 25, 2008, and is currently planned to be launched in December 2012.

LDCM consists of a single science instrument (the Operational Land Imager), a spacecraft, and a mission operations ground system. The LDCM is in formulation and system level requirements are in development to provide the following system-level performance parameters:

- Earth Spatial-Temporal Coverage: 16-day repeat coverage of the global land mass.

- Spatial Resolution: 30 meters.

- Radiometric Performance: accuracy, dynamic range, and precision sufficient to detect land cover change using historic Landsat data.

- Data: 185-km-cross-track-by-180-km-along-track multi-spectral image of Earth surface.

- Mission Life: five years.

Starting in FY2009, NASA will develop a Thermal Infrared Sensor (TIRS) instrument, to be flown on LDCM or (potentially) some other spacecraft. A decision as to which spacecraft will carry TIRS will be made by summer of 2009. Meanwhile, funding for TIRS (approximately $150-175M) is now carried within the LDCM budget.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Landsat Data Continuity Mission (LDCM)

Estimated Project Deliverables

LDCM will launch in 2012 and operate for a minimum of five years.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Operational Land Imager (OLI)	Ball Aerospace and Technology Corporation	Provide Landsat-equivalent data to extend the Landsat data of Earth's land surface for five years.	Same	Provider chosen
Spacecraft	General Dynamics	Provide performance and reliability commensurate with OLI data requirements.	Same	Same
Launch Vehicle	ULA	Provide launch service access to space.	Same	Same
Mission operations ground system	Hammers Corporation	Provide capability for command and control, mission scheduling, long-term trending and analysis, and flight dynamics analysis.	Same	Same

Estimated Project Schedule

In FY 2008, the LDCM Project awarded the LDCM spacecraft contract to General Dynamics and the Mission Operations Element (MOE) system development contract (in coordination with the USGS) to the Hammers Corporation, completing the mission complement.

In FY 2009, the LDCM Project will complete the spacecraft and MOE PDR, and the mission PDR. The OLI will undergo critical design and fabrication in FY 2009 and 2010. System integration and test will begin in FY 2011. Observatory integration and testing, as well as environmental testing, will take place in FY 2011, and launch vehicle integration will begin at the start of FY 2012.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Development			
Formulation			
Award OLI contract	June 2007	June 2007	July 2007
Confirmation Review	Jan 2008	Jan 2008	Dec 2009
Critical Design Review (CDR)	Feb 2009	Feb 2009	Apr 2010
PSR	May 2011	May 2011	Jun 2012
Launch	Jan 2011	Jan 2011	Dec 2012

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Landsat Data Continuity Mission (LDCM)

Project Management

Goddard Space Flight Center is responsible for project management. The Science Mission Directorate Program Management Council has program oversight responsibility. The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Operational Land Imager	GSFC	GSFC	None
Spacecraft	GSFC	GSFC	None
Ground System	GSFC	GSFC	U.S. Department of Interior-U.S. Geological Survey
Mission Operations	GSFC	GSFC	U.S. Department of Interior-U.S. Geological Survey

Acquisition Strategy

NASA's acquisition plan includes acquiring separate elements of the LDCM mission through open competition, with GSFC acting as the mission integrator and leading the element source selections. NASA has issued competitively selected contracts for the following major elements: to the Ball Aerospace and Technology Corporation for the development of the Operational Land Imager in July 2007, to the General Dynamics Corporation for the development of the spacecraft in April 2008, and to the Hammers Corporation for the development of the MOE in September 2008.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ and GSFC	9/2008	Systems Requirement Review (SRR) - Successful	N/A
Performance	HQ and GSFC	N/A	Mission Preliminary Design Review	7/2009

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Focal Plane Array (FPA) Development Risk	The technical risk in LDCM is low to moderate. The system component with the greatest associated risk is the Focal Plane Array (FPA). The FPA has proven flight heritage, but intrinsic development risk which could impact the LDCM schedule.	Risk mitigation strategies are based upon proven NASA methodologies that include the required instrument manufacturer risk mitigation strategy implementation and correlated Government expert oversight, an extensive peer-review process, enhanced FPA deliverables and test scenarios, and in-plant expert representation.
Manifest Uncertainty	If direction is given to add a thermal infrared sensor (TIRS) instrument to the LDCM late, the change could significantly impact the mission design, cost, and delivery schedule.	The project office has taken steps to reduce the impact by adding extra capacity to the spacecraft specification to accommodate an extra instrument. The Earth Science Division has authorized engineering and technology risk reduction work on the most probable TIRS instrument approach, so that the instrument could be ready with minimal schedule impact to the LDCM mission.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Ice, Cloud, and Land Elevation Satellite (ICESat II)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	9.6	38.8	39.2	74.6	99.1	126.9	161.7
Total Change from 2009 President's Budget Request	9.6	38.8	39.2	74.6	99.1	126.9	--

Project Purpose

The Ice, Clouds, and land Elevation Satellite II (ICESat-II) satellite will continue the measurements begun with the ICESat mission, measuring elements of ice-sheet mass balance, cloud-top and land-surface topography, to quantify polar ice sheet contributions to current and recent sea level change and the linkages to climate conditions. In addition, ICESat-II will quantify regional signatures of ice sheet changes to assess mechanisms driving that change and improve predictive ice sheet models. The science focus areas served by ICESat include: climate variability and change; earth surface and interior; and water and energy cycles.

The ICESat-II mission is one of four missions recommended for launch by NASA in the 2010-2013 time frame by the National Research Council (NRC) report entitled, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond". The ICESat-II mission will draw heavily from the original ICESat satellite launched in 2003 and still operating at the start of 2009.

For more information see http://nasascience.nasa.gov/missions/icesat2

Project Preliminary Parameters

The ICESat-II observatory employs a dedicated spacecraft with a single nadir pointing surface profiling lidar. It will be launched into a 94 deg, 91 day repeat frozen orbit.

Estimated Project Deliverables

ICESat-II is still in pre-formulation and does not yet have an official launch date; however, the pre-Phase A target launch date is late 2014/early 2015 with a notional 3 year prime mission.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Spacecraft	TBD	Competitively selected	N/A	New
Lidar Instrument	GSFC	Single beam profiling, nadir pointing	N/A	New
Launch Vehicle	TBD	Competitively selected	N/A	New

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Ice, Cloud, and Land Elevation Satellite (ICESat II)

Estimated Project Schedule

ICESat-II is still in pre-formulation. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Formulation			
Formulation			
KDP-A	N/A	N/A	September 2009
Launch readiness date (LRD)	N/A	New	Late 2014/Early 2015

Project Management

The Goddard Space Flight Center (GSFC) has project management responsibility. The Science Mission Directorate Program Management Council has programmatic oversight. The Earth Sciences Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	GSFC	TBD	TBD
Lidar	GSFC	GSFC	None
Mission Operations	GSFC	TBD	TBD
Launch Vehicle	GSFC	TBD	TBD

Acquisition Strategy

The ICESat-II lidar instrument will be built in-house at the GSFC. The spacecraft vendor will be competitively selected. The approach for the mission operations element has not yet been determined. The source and selection method for launch services will be determined later in formulation.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	ICESat-II Independent Review Team	N/A	Mission Concept Review	07/2009

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Soil Moisture Active and Passive (SMAP)

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	9.6	104.3	70.0	132.2	180.4	135.0	40.0
Total Change from 2009 President's Budget Request	9.6	104.3	70.0	132.2	180.4	135.0	--

Project Purpose

The Soil Moisture Active and Passive (SMAP) mission will provide new information on global soil moisture and its freeze/thaw states enabling new advances in hydrospheric science and applications. Direct measurements of soil moisture and freeze/thaw states are needed to improve our understanding of regional and global water cycles, terrestrial ecosystems, and the processes that link the water, energy, and carbon cycles. Soil moisture and freeze/thaw information provided by SMAP will lead to improved weather forecasts, flood and drought forecasts, and predictions of agricultural productivity and climate change, as well as improved understanding of the sources and sinks of carbon. Soil moisture and soil freeze/thaw information is useful for many purposes, so the Mission will contribute to the goals of other Earth Science Focus Areas (Carbon Cycle, Ecosystem, Weather, and Climate).

The SMAP mission is one of four missions recommended for launch by NASA in the 2010-2013 time frame by the U.S. National Research Council (NRC) report entitled, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond". SMAP is based on the soil moisture and freeze/thaw mission concept developed under the NASA Earth System Science Pathfinder (ESSP) Program Hydrosphere State (Hydros) project and builds on the Hydros formulation and technology risk mitigation studies conducted in 2003 - 2005.

For more information see http://nasascience.nasa.gov/missions/smap

Project Preliminary Parameters

The SMAP observatory employs a dedicated spacecraft with an instrument suite that will be launched into a near-polar, sun-synchronous orbit on an expendable launch vehicle. The baseline SMAP instrument suite includes a radiometer and a synthetic aperture radar operating in the L-band range (1.20-1.41 GHz) designed to make coincident measurements of soil emission and backscatter and sense the top 5 cm of soil through moderate vegetation cover. These measurements will be analyzed to yield estimates of soil moisture and freeze/thaw state. The measurements will be acquired for a period of three years, and a comprehensive validation program will be used to assess random errors and regional biases in the soil moisture and freeze/thaw estimates.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Soil Moisture Active and Passive (SMAP)

Estimated Project Deliverables

SMAP is planned for a launch in late 2013/early 2014 to begin a three-year prime mission. SMAP will make soil moisture measurements around the entire Earth every 3 days.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Spacecraft	JPL	Provides platform for the instrument	N/A	New
L-Band Synthetic Aperture Radar (SAR)	JPL	Combined with Radiometer provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	N/A	New
L-Band Radiometer	GSFC	Combined with SAR provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	N/A	New
Launch Vehicle	TBD	TBD	N/A	New

Estimated Project Schedule

SMAP entered formulation in September 2008. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2009 PB Request	FY 2010 PB Request
Formulation			
Formulation			
KDP-C	April 2010		December 2010
Launch readiness date (LRD)	March 2013		Late 2013/Early 2014

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Formulation:	Soil Moisture Active and Passive (SMAP)

Project Management

The Jet Propulsion Laboratory (JPL) has project management responsibility for SMAP. The Science Mission Directorate Program Management Council has program oversight responsibility. The Earth Sciences Division Director is the responsible official.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Spacecraft	JPL	JPL	None
L-Band Synthetic Aperture Radar (SAR)	JPL	JPL	None
L-Band Radiometer	JPL	GSFC	None
Launch Vehicle	JPL	To be determined	To be determined

Acquisition Strategy

The SMAP Spacecraft will be built in-house at JPL. The SMAP instrument, combining the Synthetic Aperture Radar (SAR) and radiometer, will be integrated by JPL. The SAR will be built by JPL. The radiometer will be built by GSFC. The Deployable Antenna/Boom and instrument spin assemblies will be procured through an open competition. The source and selection method for launch services will be determined later in formulation.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	SMAP Standing Review Board SRB	06/2008	Mission Concept Review - The SRB deemed that the SMAP project met the success criteria for the MCR.	02/2009
Performance	SMAP Standing Review Board SRB	02/2009	Mission Design Review-successfully completed.	05/2009

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Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	106.8	118.3	63.9	128.8	114.2	121.4	119.1
Aquarius	33.4	44.7	18.3	6.3	4.2	2.8	0.0
Venture Class Missions	0.0	21.0	12.9	79.2	66.5	75.1	75.7
Other Missions and Data Analysis	73.4	52.6	32.8	43.3	43.5	43.5	43.4
FY 2009 President's Budget Request	113.8	88.6	58.8	37.4	50.0	54.9	--
Orbiting Carbon Observatory (OCO)	35.6	25.4	9.0	1.4	0.0	0.0	--
Aquarius	48.6	33.8	27.9	5.1	4.0	2.9	--
Other Missions and Data Analysis	29.6	29.4	21.9	30.8	46.0	52.0	--
Changes from FY 2009 Request	-7.0	29.7	5.2	91.4	64.3	66.5	--

Note: Includes $36.6M in Recovery Act funding in FY09

Program Overview

The Earth System Science Pathfinder Program (ESSP) addresses unique, specific, highly-focused mission requirements in Earth Science research. ESSP includes a series of relatively low-to-moderate cost, small-to-medium sized, competitively selected, Principal Investigator-led missions. These missions, which are built, tested and launched in a short time interval, complement the larger Earth Systematic Missions (ESM). They are capable of supporting a variety of scientific objectives related to Earth science, including studies of the atmosphere, oceans, land surface, polar ice regions, and solid Earth. Investigations include development and operation of remote-sensing instruments and the conduct of investigations using data from these instruments.

ESSP currently has one mission in development (Aquarius) and three operating missions (Gravity Recovery and Climate Experiment [GRACE], CloudSat, and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations [CALIPSO]). Future ESSP missions will be selected from proposals submitted in response to Announcements of Opportunity.

NASA is determining how best to meet the lost science contribution after the OCO launch vehicle failure. We have initiated studies to examine both science and hardware considerations. The science study is assessing the current state of carbon cycle science and existing measurements to see what course of action would best address the key science issues. On the hardware side, NASA is examining reflight opportunities, including, but not limited to, flying an OCO-like instrument on a shared platform or as a dedicated mission.

ESSP supports missions that complement those of the larger Earth Systematic Missions which are designed to facilitate on-going or operational measurements.

For more information see http://earth.nasa.gov/essp/index.html/.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Plans For FY 2010

The Earth System Science Pathfinder (ESSP) Program plans for FY10 include completion of Aquarius/SAC-D observatory environmental testing, Operational Readiness Review and mission launch. GRACE, CloudSat, and CALIPSO will continue operations as determined by the 2009 Senior Review process. ESSP will also begin the first phase of the Venture Class mission activities.

Project Descriptions and Explanation of Changes

Aquarius

Aquarius will observe and model seasonal and year-to-year variations of sea-surface salinity and how these variations relate to changes in the water cycle and ocean circulation. The science focus areas served by Aquarius will include: climate variability and change; and water and energy cycles. Aquarius is currently in Phase C-D with a planned launch date of May, 2010 and 3 years of prime mission life. Additional detail can be found in the Aquarius section of this document.

Venture Class Missions

"Venture-class" Earth System Science Pathfinder missions have been established in response to the National Research Council's Earth Science Decadal Survey. Venture-class missions will be small, competed science investigations, and may include suborbital payloads; instruments to be flown on non-NASA spacecraft; and small, focused satellites.

Other Missions and Data Analysis

Included in this line item are three operating spacecraft:
- the Gravity Recovery and Climate Experiment (GRACE), launched in 2002, measures Earth's gravity field and its variations with time.
- CloudSat, launched in 2006, measures cloud characteristics to increase understanding of the role of optically thick clouds in Earth's radiation budget.
- The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission, launched in 2006, measures the vertical distribution of clouds and aerosols.

In addition, this line includes the ESSP research project which funds science teams for the ESSP missions. The science teams are comprised of competitively selected individual investigators who analyze data from the missions to address the related science questions.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Senior Review (SR) to make recommendations on mission extensions	GRACE, CloudSat, and CALIPSO	no change

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22		Beg	End
Aquarius																	Tech		
																	Form	Oct-03	Sep-05
																	Dev	Oct-05	Apr-10
																	Ops	May-10	May-13
																	Res		
Gravity Recovery and Climate Experiment (GRACE)																	Tech		
																	Form		
																	Dev		
																	Ops	Mar-02	Sep-11
																	Res		
CloudSat																	Tech		
																	Form		
																	Dev		
																	Ops	Apr-06	Sep-11
																	Res		
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite (CALIPSO)																	Tech		
																	Form		
																	Dev		
																	Ops	Apr-06	Apr-09
																	Res		Apr-11

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

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Program Management

The Agency Program Management Council has program oversight responsibility.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Aquarius	JPL	JPL	Argentina's Comision Nacional De Actividades Espaciales (CONAE), National Oceanic and Atmospheric Administration, Naval Research Laboratory, National Center for Atmospheric Research.
Gravity Recovery and Climate Experiment (GRACE)	Earth Science Division	JPL	Deutches Zentrum fur Luft- und Raumfahrt (DLR, the German Aerospace Center); Office National d'Etudes et de Recherches Aerospatiale (ONERA) of France; GeoForschungsZentrum (German National Research Centre for Geosciences); National Oceanic and Atmospheric Administration; National Geospatial-Intelligence Agency.
CloudSat	Earth Science Division	JPL	Canadian Space Agency; U.S. Air Force; Department of Energy.
Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)	Earth Science Division	LaRC	France's Centre National d'Etudes Spatiales (CNES, the National Center for Space Studies) and Alcatel; SODERN; Institut Pierre Simon Laplace, France.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder

Acquisition Strategy

ESSP program missions are selected competitively via Announcements of Opportunity (AO). The AO process uses peer review for the science content of the proposed missions, as well as thorough independent review of their technical, management, and cost elements.

In FY 2007, GRACE and CloudSat went through the biennial competitive Senior Review process and were approved for continued extended mission operations.

GRACE Project Team: Amarillo Independent School District; Applied Physics Laboratory, Johns Hopkins University; Llano Independent School District, Messalonskee School System; GSFC, Center for Space Research; Univ. of Texas at Austin. Analytical Mechanics Associates; Elizabeth Board of Education, Killeen Independent School District; MIT, Dept of Earth, Atmospheric & Planetary Sciences; Mid-Prairie Community School District; KSC; LaRC; Space Systems Loral; Sunray Independent School District; Texas Space Grant Consortium; Univ. of Colorado, Physics Department; Ohio State Univ., Civil & Environmental Engineering and Geodetic Science; Stanford Telecon; TRW; DJO, DASA, Jena-Optronik, Gm.

CloudSat Project Team: Colorado State Univ. PI and team, E&PO effort; Ball Aerospace ; Cooperative Institute for Research in the Atmosphere (CIRA; Colorado State Univ.) operates Data Processing Center. LaRC Atmospheric Sciences Data Center delivers data products to CIRA. GSFC delivers data products to CIRA. European Centre for Medium-Range Weather Forecasts met forecast data to CIRA. GLOBE program (Boulder, Colorado) prime education partner. USAF Space Test Program conducts mission operations out of Kirtland AFB, Albuquerque, NM.

CALIPSO Project team: LaRC systems engineering, payload mission ops, science data validation, data processing and archiving. Ball Aerospace CALIOP and wide-field camera, payload integration, LV support, science data downlink. Hampton Univ. manages quid pro quo validation effort, E&PO effort, and leads International Science Advisory Pane

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	04/2007	GRACE and CloudSat were reviewed as part of the Earth Science biennial Senior Review process. Both missions were ranked very high for data quality and relevance to the NASA Earth Science Theme objectives.	04/2009

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

FY 2010 Budget Request

Budget Authority ($ millions)	Prior	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	BTC	LCC TOTAL
FY 2010 President's Budget Request	**148.2**	**33.4**	**44.7**	**18.3**	**6.3**	**4.2**	**2.8**	**0.0**	**0.0**	**257.8**
Formulation	35.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.6
Development / Implementation	112.6	33.4	44.7	15.8	0.0	0.0	0.0	0.0	0.0	206.4
Operations / Close-out	0.0	0.0	0.0	2.5	6.3	4.2	2.8	0.0	0.0	15.8
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2009 President's Budget Request	**149.7**	**48.6**	**33.8**	**27.9**	**5.1**	**4.0**	**2.9**	**--**	**0.0**	**272.0**
Formulation	35.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	35.6
Development / Implementation	114.1	48.6	33.8	26.2	0.0	0.0	0.0	--	0.0	222.7
Operations / Close-out	0.0	0.0	0.0	1.7	5.1	4.0	2.9	--	0.0	13.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0
Changes from FY 2009 Request	**-1.5**	**-15.2**	**10.9**	**-9.6**	**1.1**	**0.2**	**-0.1**	**--**	**0.0**	**-14.2**
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	-1.5	-15.2	10.9	-10.4	0.0	0.0	0.0	--	0.0	-16.3
Operations / Close-out	0.0	0.0	0.0	0.8	1.2	0.2	-0.1	--	0.0	2.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0

Note: The FY 2010 LCC number in the table above is understated by $2.2M due to the difference in the FY09 enacted bill and the April 2009 initial operating plan. Assuming approval of NASA's Initial Operating Plan for FY 2009, the estimated lifecycle cost of Aquarius will be $260.0M, a reduction of $12.0M from last year's estimate; the estimated Development cost will be $208.6M.

Explanation of Project Changes

The FY 2009 Budget for Aquarius reflected early estimates for the cost of the launch delay from July 2009 to May 2010. While the launch remains planned for May 2010, current cost trends and revised estimates are lower than budgeted last year.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

Project Purpose

The Aquarius mission will investigate the links between the global water cycle, ocean circulation, and climate. It will observe and model variations of sea surface salinity, and how these relate to changes in the water cycle and ocean circulation. This will yield an unprecedented view of the oceans' role in climate and weather.

For more information visit: http://aquarius.gsfc.nasa.gov/

Project Parameters

Aquarius is an instrument on Argentina's National Committee of Space Activities (CONAE) spacecraft, Satellite de Aplicaciones Cientificas-D (SAC-D). The combined NASA and CONAE instruments and spacecraft form the Aquarius/SAC-D observatory. This observatory will be launched into a polar, Sun-synchronous orbit that allows global coverage of ice-free ocean surfaces consistent with Aquarius/SAC-D science observational targets. The Aquarius instrument includes an L-band microwave radiometer (1.413 GHz) and scatterometer (1.26 GHz). The radiometer will measure the surface brightness temperature, which is related to the surface emissivity and physical temperature of the seawater. The surface emissivity is determined by the dielectric constant of seawater, which is related to salinity. The scatterometer is required to provide coincident information of sea surface roughness, a critical correction term for retrieval of sea surface salinity.

Project Commitments

Aquarius will launch in May 2010 to begin a three-year prime mission to measure sea surface salinity (SSS) with the precision, resolution, and coverage needed to characterize salinity variations and investigate the linkage between ocean circulation, Earth's water cycle, and climate variability.

Project Element	Provider	Description	FY 2009 PB Request	FY 2010 PB Request
Aquarius Instrument (integrated radiometer/ scatterometer)	JPL	L-band microwave radiometer at 1.413 GHz; scatterometer at 1.26 GHz; SSS measurements with root-mean-sq random errors and systematic biases <= 0.2 psu on 150 km sq scales over ice-free oceans.	Same	Same
Spacecraft	CONAE	SAC-D	Same	Same
Launch Vehicle	Boeing	Delta II	Same	Same
Data Management	GSFC	N/A	Same	Same
Operations	CONAE	Command and telemetry	Same	Same

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

Schedule Commitments

The Aquarius mission entered a Risk Mitigation Phase (RMP) in July 2002. Following the RMP, the project was authorized to proceed to a formulation phase in December 2003. The Aquarius mission was authorized by the NASA Science Mission Directorate to proceed to Development on October 12, 2005. In November 2007, the NASA Science Mission Directorate Program Management Council approved a rebaseline of Aquarius, including a launch delay to May 2010.

Milestone Name	Confirmation Baseline	FY 2009 PB Request	FY 2010 PB Request
Development			
Mission Confirmation Review	September 2005	September 2005	September 2005
Mission CDR	August 2007	April 2008	July 2008
Aquarius Instrument Pre-ship Review [FY08 APG]	May 2008	May 2008	May 2009
Launch	March 2009	May 2010	May 2010

Development Cost and Schedule Summary

Project	Base Year	Base Year Development Cost Estimate ($M)	Current Year	Current Year Development Cost Estimate ($M)	Cost Change (%)	Key Milestone	Base Year Milestone Date	Current Year Milestone Date	Milestone Change (months)
Aquarius	2007	192.6	2009	208.6	8	Launch Readiness	7/1/2009	5/1/2010	10

Development Cost Details

Element	Base Year Development Cost Estimate ($M)	Current Year Development Cost Estimate ($M)	Delta
Total:	**192.6**	**208.6**	**16.0**
Payloads	55.4	88.1	32.7
Launch Vehicle/Services	78.9	76.1	-2.8
Ground Systems	5.5	4.3	-1.2
Science/Technology	10.9	9.6	-1.3
Other Direct Project Cost	41.9	30.5	-11.4

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth System Science Pathfinder
Project In Development:	Aquarius

Project Management

The Jet Propulsion Laboratory is responsible for project management. The Science Mission Directorate Program Management Council is responsible for program oversight.

The Earth Science Division Director is the responsible official for this project.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Launch Vehicle	KSC	KSC	None
Ground System	JPL	GSFC	None
Aquarius Instrument	JPL	JPL	None
Spacecraft	CONAE	None	CONAE
Radiometer	JPL	GSFC	None
Data management	GSFC	GSFC/JPL	None
Mission operations	CONAE	None	CONAE

Acquisition Strategy

Aquarius was competitively selected from proposals submitted in response to Earth System Science Pathfinder (ESSP) Announcement of Opportunity 3. All elements of the project were included in that selection, and there are no other planned major procurements.

The launch vehicle procurement was awarded to Boeing. Goddard Space Flight Center and the Jet Propulsion Laboratory were selected for the remaining project elements not provided by CONAE.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	Aquarius Standing Review Board	7/2008	Mission Critical Design Review (CDR) was successful	N/A
Performance	Aquarius Standing Review Board	N/A	System Integration Review (SIR)	05/2009

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Spacecraft Development Delays	Further delays could impact launch date.	Monitor COMISION NACIONAL DE ACTIVIDADES ESPACIALES (CONAE) Progress and confirm commitments; reassess available schedule reserves.

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Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	143.0	148.1	149.9	160.3	165.4	161.3	165.5
Earth Science Multi-Mission Operations	143.0	148.1	149.9	160.3	165.4	161.3	165.5
FY 2009 President's Budget Request	167.8	140.5	159.1	157.9	166.5	170.9	--
Earth Science Multi-Mission Operations	167.8	140.5	159.1	157.9	166.5	170.9	--
Changes from FY 2009 Request	-24.8	7.5	-9.2	2.4	-1.1	-9.5	--

Note: Includes $7.5M in Recovery Act funding in FY09

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Program Overview

The Earth Science Multi-Mission Operations Program acquires, preserves, and distributes observational data to support Earth Science focus areas in conformance with national science objectives. The Earth Science focus areas are as follows: (1) Climate variability and change; (2) Atmospheric composition; (3) Carbon cycle, ecosystems, and biogeochemistry; (4) Water and energy cycles; (5) Weather; and (6) Earth surface and interior. Facilities involved in this undertaking include data-handling, data processing, and archiving systems.

NASA's principal Earth Science information system is the Earth Observing System Data and Information System (EOSDIS), which has been operational since August 1994. EOSDIS acquires, processes, archives, and distributes Earth Science data and information products created from satellite data, which arrive at the rate of more than four trillion bytes (4 terabytes) per day. Having successfully created this system, NASA is using advances in information technology to expand its capabilities while providing continuous service to the user community.

The Evolution of EOSDIS Elements (EEE) effort is increasing efficiency and operability; increasing data usability by the research, application, and modeling communities; providing services and tools needed to enable use of NASA's Earth Science data in next-decadal models, research results, and decision support system benchmarking; and improving support for end users. The evolved system is being phased in -- a process that began in FY 2006 -- with milestones developed through 2008. The budget request for FY 2010 incorporates cost savings that will result from this effort. A system plan for 2015 will guide further improvements. Very modest investments will enable the system to keep technologically current, and incorporate new research data and services.

NASA Earth Science information is archived at eight Distributed Active Archive Centers (DAACs) located across the United States. The DAACs specialize by topic area, and make their data available to researchers around the world. For more information, please see http://eos.nasa.gov/eosdis.

Research opportunities related to EOSDIS are available through the Advanced Collaborative Connections for Earth System Science (ACCESS) at http://access-projects.gsfc.nasa.gov/ and Making Earth System data records for Use in Research Environments (MEaSUREs) at http://measures-projects.gsfc.nasa.gov/ programs. Participants in these programs are solicited through the Research Opportunities in Space and Earth Sciences (ROSES), the NASA Research Announcement soliciting basic and applied research proposals.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Plans For FY 2010

The Earth Science Multi-Mission Operations Program will continue operation of EOSDIS, the DAACs and their accompanying functions, as well as Core System Science Data Processing Systems. The maintenance of these systems is important to the collection of data from Earth Science satellites in orbit, as well as to the continuity of Earth Science research efforts.

The Step 1 Evolution of EOSDIS Elements (EEE) effort, begun in 2006, is essentially complete. Savings and operational benefits from the Step 1 are being realized in FY 2009 and beyond. NASA plans to continue the support of the EEE to enable a service oriented architecture between now and 2015.

Five-year MEaSUREs Projects began work in 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. A new Advanced Collaborative Connections for Earth System Science (ACCESS) solicitation is being readied for NASA's Research Opportunities in Space and Earth Sciences - 2009 (ROSES-2009). These Cooperative Agreements are proving very valuable for keeping research and modeling communities actively involved with the EOSDIS architecture, and informing core infrastructure evolution decisions.

Project Descriptions and Explanation of Changes

EOSDIS

EOSDIS is the central data handling system for NASA's Earth Science efforts. EOSDIS components funded in the project include:

* Production of standard science data products, using algorithms and software developed by EOS investigators;

* Active archive of data, as well as ordering, distribution, and data management. Also ensures the preservation of data, products, related algorithms, and system-configuration history;

* Information Management, enabling researchers to rapidly locate and retrieve data critical to their work; and

* User Support for research scientists, educators, students, and users in public agencies responsible for operational applications of the data, as well as for the general public.

Nominal EOSDIS development ended in FY 2007. All future development and improvements to the system will be planned through the Evolution of EOSDIS Elements process.

The Precipitation Processing System (PPS) is a measurement-based data and information system at GSFC that evolved from the TRMM Science Data and Information System (TSDIS). PPS continues to support the TRMM Science Team with analyzed rainfall data from TRMM as well as data from other precipitation instruments, and is also developing further to support the upcoming Global Precipitation Mission (GPM) to be launched in 2013.

Earth Science Multi-Mission Operations

This project funds the Elements of EOSDIS Evolution, aimed at improving the efficiency and effectiveness of EOSDIS while reducing the cost, and the Distributed Active Archive Centers, which collect, disseminate, and archive Earth Science data at eight centers across the Nation:
-The Alaska SAR Facility, which collects Synthetic Aperture Radar data, and information on sea ice, polar processes, and geophysics;
-The GSFC Earth Sciences Data and Information Services Center, which collects information on atmospheric composition, atmospheric dynamics, global precipitation, ocean biology, ocean dynamics, and solar irradiance;
-The Langley Research Center DAAC, which collects data on Earth's radiation budget, clouds, aerosols, and tropospheric chemistry;
-The Land Processes DAAC, which collects land processes data;
-The National Snow and Ice Data Center, which collects snow and ice data, as well as information about the cryosphere and climate;
-The Oak Ridge National Laboratory DAAC, which collects data on biogeochemical dynamics, and ecological data for studying environmental processes;
-The Physical Oceanography DAAC, which collects information on oceanic processes and air-sea interactions; and
-The Socioeconomic Data and Applications Center, covering population, sustainability, multilateral environmental agreements, natural hazards, and poverty.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Provide services and tools needed to enable use of NASA's Earth Science data in next-decadal models, research results, and decision support system benchmarking.	EOSDIS and DAACs	None.

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates		
	Prior	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22		Beg	End
EOSDIS and Multi-Mission Operations (including DAACs)																	Tech Form Dev **Ops** Res	Aug-94	Dec-15
Elements of EOSDIS Evolution (phased start-up beginning in FY 2008)																	Tech Form Dev **Ops** Res	Nov-04 Dec-05 Apr-08	Nov-05 Mar-08 Dec-20

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

Program Management

The Science Mission Directorate and the Program Management Council have oversight responsibility for this program. The Earth Science Data and Information System Project Office at GSFC has primary responsibility for the program.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Precipitation Processing System (PPS)	GSFC	GSFC	NASA operates and is further developing the PPS to provide analyzed data from the TRMM and GPM missions. Both TRMM and GPM are joint missions of NASA and JAXA, a key stakeholder
ACCESS, MEaSUREs (peer-reviewed data research opportunities)	SMD	NASA Headquarters	None.
Multi-Mission Operations (operations and maint. of Core EOSDIS systems; DAACs, Evolution of EOSDIS)	GSFC	Earth Science Data and Information Systems Office, Goddard Space Flight Center	Key participants in the Multi-Mission Operations project include the space agencies of Europe, Canada, Germany, France, and Japan. Other U.S. agency partners include the National Oceanic and Atmospheric Administration (Department of Commerce), U.S. Geological Survey (Department of the Interior), and the Department of Defense.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Multi-Mission Operations

Acquisition Strategy

The EOSDIS Core System is a high-performance software system that provides science data ingest, archive and distribution capabilities for a multitude of Earth science instruments. Maintenance and operations for this system, utilized by three DAAC's post-Step 1 Evolution of EOSDIS Elements, is performed under contract procured by GSFC. The contract, managed by the ESDIS Project at GSFC, will be recompeted during this year

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	Earth Science Subcommittee	1/2008	The Earth Science Subcommittee reported that they were impressed by the success and clear sense of direction of this program.	TBD
Quality	DAAC Data Priority Workshops	01/2006	DAAC archive holdings peer reviewed for scientific merit. Multiple reviews related to individual research areas, all successful, several recommendations in work.	TBD

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Technology

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	43.0	54.1	45.9	47.2	48.2	49.5	52.7
Earth Science Technology	43.0	54.1	45.9	47.2	48.2	49.5	52.7
FY 2009 President's Budget Request	47.3	46.1	49.2	50.6	51.6	52.8	--
Earth Science Technology	47.3	46.1	49.2	50.6	51.6	52.8	--
Changes from FY 2009 Request	-4.3	8.0	-3.3	-3.3	-3.3	-3.3	--

Note: Includes $8M of Recovery Act funding in FY09

Program Overview

Advanced technology plays a major role in enabling Earth research and applications programs by providing an improved understanding of the total Earth system and its effects of natural and human-induced changes on the global environment. The Earth Science Technology Program (ESTP) provides the Earth Science Division with new capabilities, enabling previously unforeseen and infeasible science investigations, enhancing existing measurement capabilities, and reducing the cost, risk, and development times of Earth science measurements.

The Earth Science Technology Office (ESTO) provides strategic, science-driven technology assessments and requirements development. The program implements a science focused technology program by pursuing promising scientific and engineering concepts through open competition solicitations.

For more information, please see: http://esto.nasa.gov

Plans For FY 2010

ESTP will plan and implement development of new remote-sensing and information systems technologies for infusion into future science missions in order to enable, or dramatically enhance, measurements and data system capabilities. Planning will start with measurement priorities established by the science community, leading to systematically developed technology requirements and priorities. Studies may be conducted to assess measurement options for meeting technology performance requirements. Implementation will be performed through managing awarded tasks from competed solicitations in the three project areas: Instrument Incubator, Advanced Information Systems, and Advanced Technology Initiatives. Ongoing activities in these areas are described in more detail in the project description section below.

For FY2010 new work will only be solicited in the Instrument Incubator area. This FY2010 solicitation is planned to be part of the ROSES-2009 NASA Research Announcement. The solicitation will be a call for Earth science instrument system technology to address the measurements called for in the NRC Decadal Survey.

Project Descriptions and Explanation of Changes

Instrument Incubator

This project develops new and innovative instruments and measurement techniques at the system level, including laboratory development and airborne validation.

A solicitation for new instrument technologies was released in FY2007 and 21 new awards were made for sensors measuring atmospheric trace gases, aerosols, clouds, gravity fields, ocean topography, tropospheric winds, thermal land imaging, Earth radiation balance, precipitation, ocean color, snow, and vegetation. Instrument technologies include imagers, spectrometers, lidars, microwave sounders, and radars. These projects started in FY2008 and will continue through FY2011.

Some notable recent Instrument Incubator demonstrations include airborne radar measurements of Greenland ice sheet basal topography from high altitude and in two dimensions, the first simultaneous lidar measurements of tropospheric water vapor and aerosols from an aircraft, a ground-based demonstration of the hybrid Doppler wind lidar with simultaneous coherent and direct detection measurements, and airborne Ka-band interferometric synthetic aperture radar (SAR) topography measurements.

Advanced Information Systems Technology

This project develops end-to-end information technologies that enable new Earth-observation measurements and information products. The technologies are used to process, archive, access, visualize, communicate, and understand science data.

A solicitation released in June 2008 awarded 20 additional projects in early FY09, focused on three areas needed to support future Earth science measurements: Sensor System Support (to incorporate autonomy and rapid response in the sensing process and improve the science value of data); Advanced Data Processing (to improve or enhance the information extracted from the data stream); and Data Services Management (to better manage the growing body of Earth science data and allow for efficient exchange).

As examples, one project team deploys a fleet of SnoMote robots to test their mobile sensor network on Mendenhall Glacier in Alaska; the autonomous SnoMotes are designed to gather in-situ science data in dangerous, volatile ice environments to augment remote sensing data with accurate ground-truth measurements. Another task develops an inter-operable sensor architecture system that integrates four satellites, a UAV, and multiple ground sensors, data algorithms, and models, and has been demonstrated as a tool to help manage wildfires.

Advanced Technology Initiatives

The Advanced Technology Initiatives element provides for the development of critical component and subsystem technologies for the instruments and platforms which support the Earth Science Decadal Survey.

In 2008, the Advanced Technology Program solicited, via ROSES, for technologies such as: space-qualifiable laser transmitters, passive optical technologies, microwave and calibration technologies. Sixteen awards were made, supporting 14 of the 15 NASA Earth Science Decadal Survey missions. Some examples of these awards follow. A corrugated mirror telescope array for lidar will support seven of the Decadal Survey missions and help to enable the measurement of ice, crustal deformation, carbon dioxide and even 3D winds. Another notable technology is a large aperture deployable reflector which will support: soil moisture, ocean and river water dynamics, temperature and humidity soundings and snow accumulation for fresh water assessments. Other awards support measurements of: solar radiance, ozone, aerosols, atmospheric gas columns for air quality and ocean color for coastal ecosystem health and climate emissions.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Annually advance a portion of funded technology developments by one technology readiness level.	ESTP	same
Annually mature several technologies to the point of readiness for demonstration.	ESTP	same
Annually enable or improve one new science measurement capability.	ESTP	same

Program Management

The Earth Science Division within the Science Mission Directorate has oversight responsibility of the program office.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Instrument Incubator	ESTO	GSFC, JPL, LaRC, ARC, GRC	None.
Advanced Info Systems	ESTO	GSFC, JPL, LaRC, ARC, GRC	None.
Advanced Tech Initiatives	ESTO	GSFC, JPL, LaRC, ARC, GRC	None.

Acquisition Strategy

Tasks are procured primarily through full and open competition, such as the Research Opportunities in Space and Earth Sciences (ROSES)announcements.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Science Technology

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NAC - Science Committee	10/2008	Technology in support of Decadal Survey missions	10/2010

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

FY 2010 Budget Request

Budget Authority ($ millions)	FY 2008 Actual	FY 2009 Enacted	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014
FY 2010 President's Budget Request	40.2	47.8	32.2	30.7	31.5	32.2	33.1
Pathways	40.2	47.8	32.2	30.7	31.5	32.2	33.1
FY 2009 President's Budget Request	45.4	33.8	33.8	31.3	32.1	32.8	--
Pathways	45.4	33.8	33.8	31.3	32.1	32.8	--
Changes from FY 2009 Request	-5.2	14.0	-1.6	-0.6	-0.6	-0.6	--

Note: Includes $4M of Recovery Act funding in FY09

Program Overview

The Applied Sciences Program (http://nasascience.nasa.gov/earth-science/applied-sciences) leverages NASA Earth Science research and observations for practical use, such as resource management and planning, decision-making, and improved predictions and policies. NASA Applied Sciences projects are designed to provide tools for improved decision making, through which the nation can better manage its resources, improve life quality, and strengthen the economy. NASA develops Earth Science applications in collaboration with end-users in public, private, and academic organizations. Examples include improved public health tracking systems for deadly diseases with the Center for Disease Control; advances in prediction of weather conditions for airplane pilots through the National Weather Service and the Federal Aviation Administration; improved tracking of air pollutants with the Environmental Protection Agency for decision-making on biomass burning and industrial practices; improving the Department of Agriculture's Global Economic Forecasting; and providing tools for better disaster management by state and local first responders..

Plans For FY 2010

In FY10, the Applied Sciences Program will continue or initiate projects across a range of application areas, including climate, public health, ecosystems forecasting, air quality, weather, water resources, natural disasters, and agriculture. These projects have been competively selected through NASA's Research Opportunities in Space and Earth Science (ROSES) 2005, 2007, and 2008 research announcements.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

Project Descriptions and Explanation of Changes

Applied Sciences

In 2010, the Applied Sciences Program will sponsor two types of competitively selected projects across the range of applications described above:

1. "Decision Support through Earth Science Research Results. " These are 3-4 year projects that are carried out collaboratively with end users; the outcome of Decisions projects is to demonstrate and substantiate improvements to the end-users decision making activities.

2. "Earth Science Applications Feasibility Studies." These are short term projects to test the technical or the organizational feasibility of a new application.

The project also includes a small number of activities that crosscut and support the tasks, including cross-cutting projects,workforce development, and outreach.

Program Commitments

Commitment/Output FY 2010	Program/Project	Changes from FY 2009 PB Request
Issue competed peer reviewed research awards.	Applied Sciences	None
Maximize resource utilization through restructuring and streamlining processes and operations across the program.	Applied Sciences	None

Program Management

Applied Sciences Program responsibility resides within the Earth Science Division of the Science Mission Directorate.

Project	Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Earth Science Applications	NASA HQ	GSFC, LaRC, SSC, JPL, MSFC, and ARC	EPA, NOAA, USDA, FAA, DOE, DOI, CDC, USAID ; state agencies, and regional organizations such as the Southern Governor's Growth Policy Board, American Water Resources Association, Gulf of Mexcio Alliance. Private sector and universities.

Acquisition Strategy

The Earth Science Applications Program is based on full and open competition. Grants are peer reviewed and selected based on NASA Research Announcements and other related announcements.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Applied Sciences

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	National Research Council	10/2007	The Applied Sciences Program strategy and implementation.	N/A
Relevance	Applied Science Analysis Group	N/A	Applied Sciences program strategy and implementation.	12/2009

Program Risk Management

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