

Theme Overview

NASA's Earth Science Theme advances knowledge of the integrated Earth systems. 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. A key strategic element is sustained simultaneous observations to unravel the complexity of the global integrated Earth system. The program has four major elements: Flight Programs (Earth Systematic Missions and Earth System Science Pathfinder) develop satellite missions; Earth Science Research advances scientific understanding and identifies 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 effective use of Earth science measurements and scientific understanding by other Federal, state, local and tribal organizations.

The President's budget significantly advances NASA's climate-related activities through expansions of targeted activities in the Research, Applied Sciences, and Technology areas as well as acceleration of launches and selected additions to the flight portfolio. The budget enables launch of all Tier-1 Decadal Survey missions by late CY2017, expands the Venture-class competitive program with annual solicitations, initiates development of key climate continuity missions to mitigate data gaps, and identifies and accelerates Tier-2 Decadal Survey and related missions for flights on selected platforms including the ISS.

NASA presently operates fifteen satellite missions; thirteen are acquiring well-calibrated global observations with high-spatial and high-temporal resolution, while two (ICESAT, QuiKSCAT) recently ended their main scientific missions and are providing degraded measurements for use in cross-calibration and engineering investigations. NASA aircraft and surface-based instruments calibrate, complement, and enhance interpretation of satellite measurements. NASA supports 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 seven missions in formulation and development. With this FY2011 budget, the first two Decadal Survey missions (SMAP, ICESAT-2) have accelerated launch readiness dates of late CY2014 and late CY2015 respectively and scientifically focused CLARREO and DESYDyNl (both Radar and Lidar) missions will be launched by the end of CY2017. Launch of all four Decadal Survey Tier-1 missions is achieved by 2017 and within a three-year span allowing on-orbit overlap. Selected Tier-2 Decadal Survey climate-focused missions will be identified by NASA in conjunction with the US Global Change Research Program, and initiated in this budget period for launch in the 2019-2020 timeframe. Recognizing the broad societal and policy impact of NASA's Earth observations, NASA will initiate development of two missions to continue and enhance climate time series. NASA will start the refurbishment of an atmospheric chemistry instrument to be hosted by the International Space Station as early as 2013, and will initiate a GRACE Follow-on mission to continue the gravity measurements provided by the aging Gravity Recovery and Climate Experiment (GRACE), for a launch in late FY2016.

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	<u>1,702.3</u>	<u>1,420.7</u>	<u>1,801.8</u>	<u>1,944.5</u>	<u>2,089.5</u>	<u>2,216.6</u>	<u>2,282.2</u>
Earth Science Research	437.4	383.3	438.1	489.6	513.6	523.4	543.3
Earth Systematic Missions	893.7	723.4	809.3	993.9	1,120.8	1,226.8	1,223.5
Earth System Science Pathfinder	122.1	86.0	303.8	204.3	196.4	190.1	228.9
Earth Science Multi-Mission Operations	146.0	149.9	161.2	164.5	160.5	165.8	169.8
Earth Science Technology	55.3	45.9	52.8	53.9	57.1	64.7	68.0
Applied Sciences	47.8	32.2	36.6	38.3	41.1	45.9	48.7
FY 2010 President's Budget Request	<u>1,704.6</u>	<u>1,405.0</u>	<u>1,500.0</u>	<u>1,550.0</u>	<u>1,600.0</u>	<u>1,650.0</u>	--
Earth Science Research	437.4	397.5	407.5	404.2	416.8	412.1	--
Earth Systematic Missions	898.9	715.5	725.4	786.4	818.8	867.6	--
Earth System Science Pathfinder	118.3	63.9	128.8	114.2	121.4	119.1	--
Earth Science Multi-Mission Operations	148.1	149.9	160.3	165.4	161.3	165.5	--
Earth Science Technology	54.1	45.9	47.2	48.2	49.5	52.7	--
Applied Sciences	47.8	32.2	30.7	31.5	32.2	33.1	--
Total Change from FY 2010 Request	-2.2	15.7	301.8	394.5	489.5	566.6	--

Plans for FY 2011

Earth Science Research

NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat and ICESat-2 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 2010 (ROSES-10), a research announcement covering all of the planned research solicitations in Earth Science Research. The FY 2011 budget will fund research competitively selected in FY 2010 under this ROSES call. 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 2011 will be tasks initiated in FY 2009 and FY 2010 based on solicitations included in ROSES-08 and ROSES-09, respectively. Selections based on ROSES 08 and 09 solicitations are on-going and are addressing a number of Earth Science research areas, including biodiversity, ocean salinity, hurricane and precipitation science, remote sensing of water quality, atmospheric composition, and interdisciplinary science.

In addition, the Research Program develops and tests experimental techniques and algorithms that contribute to future Decadal Survey missions. The FY 2011 President's Budget will enhance support for interdisciplinary science and NASA contribution to observational and model-based contributions to national and international climate assessments as well as support increased investments in scientific computing and space geodesy.

Plans for FY 2011

Earth Systematic Missions

In FY 2011, the President's budget accelerates or initiates Systematic Missions recommended by the National Research Council's 2007 Decadal Survey. The Soil Moisture Active-Passive (SMAP) and Ice, Cloud, and Land Elevation Satellite (ICESat-2) missions will be accelerated for launches in late CY 2014 and late CY 2015 respectively. Phase A formulation activities will be initiated for the remaining Tier-1 Decadal Survey missions, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI), for accelerated launches in CY 2017. In addition, in conjunction with the USGCRP, NASA will identify at least one key climate-related Tier-2 Decadal Survey missions and initiate pre-formulation activities toward a late CY 2017 launch.

The following other activities will be undertaken or accomplished in FY 2011:

- GPM will complete its SIR and KDP-D;
- NPP will complete its satellite pre-ship review and is scheduled to launch (Sep 2011);
- Glory spacecraft will launch;
- LDCM will deliver the Operational Land Imager (OLI) instrument to the spacecraft;
- LDCM will complete its spacecraft integration and test;
- SMAP will complete KDP-C and enter into development;
- ICESat-2 will complete KDP-B and initiate the spacecraft contract;
- DESDynI and CLARREO will enter in Phase A formulation;
- The new GRACE Follow-on continuity mission will complete a pre-formulation phase and enter in Phase A formulation;
- The SAGE III instrument will begin refurbishment and will complete ISS accommodation assessment;
- Production of a dual payload adapter capability for the NASA launch services EELV fleet will be initiated, allowing dual-launch of DESDynI Radar and Lidar spacecraft; and
- A biannual Senior Review of all operating Earth research missions beyond their baseline mission duration will be conducted to optimize operating mission resources allocations in light of mission technical issues, time series continuity priorities, and mission contributions to non-NASA national imperatives such as improved weather forecasts.

Plans for FY 2011

Earth System Science Pathfinder

The Earth System Science Pathfinder (ESSP) Program plans for FY 2011 include completion of Aquarius/SAC-D observatory environmental testing, delivery to the launch site and launch of the Aquarius/SAC-D mission, and the start of the first series of Venture-class airborne science PI missions, selected in FY 2010. FY 2011 will see the completion of preparations for two additional competitive announcements within the Venture line in the ESSP program, one for a orbital mission and a second for an instrument of opportunity. In FY 2011, NASA will initiate the accelerated development of an Orbiting Carbon Observatory (OCO) Reflight (OCO-2) mission in October 2010, with the objective to launch in Feb 2013.

The following other activities will be undertaken or accomplished in FY 2011:

- The Aquarius/SAC-D mission will complete its environmental tests and launch from the Vandenberg Air Force Base (VAFB);
- The Orbiting Carbon Observatory - 2 (OCO-2) mission will conduct its confirmation review in October 2010, followed by the start of the mission development, leading to a target launch readiness date of Feb 2013;
- The start of the 1st Venture class missions, the EV-1 selections, in airborne science for sustained campaigns;
- Complete preparations for the 2nd Venture mission call and for the release of a Venture flight instrument AO, both to be released at the start of FY 2012; and
- GRACE, CloudSat, and CALIPSO will continue operations as determined by the 2009 Senior Review process, with extensions approved through the end of FY 2011. These missions will complete an additional Senior Review cycle in FY 2011 for operations in FY 2012 and beyond.

Earth Science Multi-Mission Operations

The Earth Science Multi-Mission Operations Program will continue operation of the Earth Observing System Data and Information System (EOSDIS), the Distributed Active Archive Centers (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. NASA plans to continue the support of the Evolution of EOSDIS Elements effort to enable a service oriented architecture between now and FY 2015.

Five-year MEaSURES Projects began work in FY 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. An Advanced Collaborative Connections for Earth System Science (ACCESS) solicitation was released in NASA's Research Opportunities in Space and Earth Sciences - 2009 (ROSES-2009), and selections were made for new ACCESS Projects beginning in FY 2010. A third program solicitation, Earth System Data Records Uncertainty, is being readied for ROSES-2010, with selections planned to begin in FY 2011. 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.

Plans for FY 2011

Earth Science Technology

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. The FY 2011 President's Budget supports expansion of the currently planned activities.

For FY 2011, new work will be solicited in the Advanced Information Systems Technology and Advanced Component Technology areas. This FY 2011 solicitation will be part of the ROSES-2011 NASA Research Announcement. Both calls will support the NRC Decadal Survey missions and measurements.

Applied Sciences

In FY 2011, the Applied Sciences Program will continue or initiate projects across a range of application areas, including agriculture, air quality, climate, ecological forecasting, public health, natural disasters, water resources, and weather. These projects are competitively selected through NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2007, 2008, 2009, and 2010. In FY 2011, the Program will feature increased joint solicitations with research and end-user organizations, representation in satellite mission teams, and continuation of capacity building efforts to build skills and capabilities on how to access and apply Earth observations data to benefit society. The FY 2011 President's Budget enables the Program to introduce a new solicitation, increase the number of project selections, increase end-user involvement in early phase mission planning, and expand the SERVIR network.

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. Global Change Research Program. U.S. science community priorities are expressed in National Research Council's decadal survey report Earth Observations and Applications from Space: National Imperatives for the Next Decade and Beyond (NRC, 2007). NASA is working to implement the recommendations of in this report.

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 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. NASA is the largest contributor to the Global Learning and Observations to Benefit the Environment (GLOBE), an international program that involves students in making hands-on observations of the Earth's environment and sharing them as part of an international community of learners. The DEVELOP program (not an acronym) is a national high school and university student-led, student-run internship activity. NASA'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:

A team of NASA researchers at the Goddard Institute for Space Studies found that two greenhouse gases, methane and carbon monoxide, have a significantly more powerful warming impact than previously thought. In a paper published in October, the team conducted one of the first modeling experiments to rigorously quantify the impact of greenhouse gas-aerosol interactions on climate and air quality. The study found that methane's global warming impact has been underestimated, and that the combined impact of emissions that cause both warming and air pollution have as much warming effect as carbon dioxide. This improved knowledge of the warming effect of these greenhouse gases will help policymakers devise more efficient climate change mitigation strategies, which to date have concentrated only on curbing carbon dioxide.

Using NASA satellite data, scientists found that groundwater levels in northern India have been declining by as much as 1 foot per year over the past decade. A team of hydrologists led by Matt Rodell of NASA's Goddard Space Flight Center found that northern India's underground water supply is being pumped and consumed by human activities, such as irrigating cropland, and is draining aquifers faster than natural processes can replenish them. The finding is based on data from NASA's Gravity Recovery and Climate Experiment (GRACE), a pair of satellites that sense changes in Earth's gravity field. These changes directly relate to changes mass distribution, including water masses stored above or below Earth's surface.

NASA's Operation Ice Bridge, a six-year airborne field campaign, is the largest airborne survey of Earth's polar ice ever flown. It will yield an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves and sea ice. NASA completed the campaign's first Arctic survey in November 2009 from a base in Greenland and its first Antarctic survey this fall from Chile. Data collected during the campaign will help bridge the gap in critical space-based observations between the imminent end of NASA's Ice, Cloud, and Land Elevation Satellite (ICESat) mission, and ICESat-2, which is scheduled to launch in CY 2015.

Over its 10 years in orbit, NASA's Terra Earth-observing satellite has turned up trends and science results that are helping researchers better understand the complex Earth system. Researchers have updated Earth's energy budget, showing the world is cloudier than we thought, aerosols have an ambiguous yet critical role in climate, and not all urban areas attract and store heat in the same way. Other atmospheric discoveries have helped researchers show how high and far pollution travels.

Independent Reviews:

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	NASA Advisory Council (NAC)	10/2009	NASA Advisory Council (NAC) - Review science strategy and implementation strategy for the Earth Science programs	02/2010
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. For more information: http://www.nap.edu/catalog.php?record_id=11820	2016

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	437.4	383.3	438.1	489.6	513.6	523.4	543.3
Earth Science Research and Analysis	313.7	278.9	324.6	348.2	365.9	391.0	406.4
Computing and Management	123.7	104.4	113.5	141.4	147.8	132.4	136.9
FY 2010 President's Budget Request	437.4	397.5	407.5	404.2	416.8	412.1	--
Earth Science Research and Analysis	313.7	281.7	300.3	294.2	304.4	296.5	--
Computing and Management	123.7	115.8	107.2	110.0	112.4	115.6	--
Changes from FY 2010 Request	0.0	-14.2	30.5	85.3	96.8	111.3	--

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://nasascience.nasa.gov/earth-science/>.

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

Plans For FY 2011

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 2010 (ROSES-10), a research solicitation released February 2010. Solicited research in CY 2010 will generally result in grants funded with FY 2011 funding and two subsequent years, and includes ocean biology and biogeochemistry, physical oceanography, and other field experiments. It will also continue funding research solicited in ROSES-09 and ROSES-08 as they have progressed in their 2nd and 3rd year, respectively. The research portfolio includes the Interdisciplinary Science project, also competed in ROSES, 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 and the Earth science education and outreach activity. 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.

The FY 2011 President's budget enhances support for interdisciplinary science, increase NASA's contribution to observational and model-based contributions to national and international climate assessments as well as support increased investments in scientific computing and space geodesy.

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. The FY 2011 President's budget will enable a new investment in support of national and international climate assessments

Airborne Science: Airborne Science funds NASA's Earth science aircraft, both manned and unmanned. 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 characterize extreme weather events (e.g., hurricanes), observe Earth system processes, capture data for Earth science modeling activities, and calibrate the instruments flying aboard Earth science spacecraft. NASA has already begun a new Airborne Science campaign, called IceBridge, to "bridge the gap" between ICESat and ICESat-2 data. This activity, focusing on changes in Greenland, Arctic, and Antarctic ice, will continue in FY 2011 and beyond.

Interdisciplinary Science: Interdisciplinary Science funds science teams, support for which will be increased as part of the FY 2011 President's budget, 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 consistent, calibrated ozone time series that can be used for trend analyses and other studies.

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

Earth Science Research and Analysis (continued)

Education and Outreach Activity: The Education and Outreach Activity supports NASA's educational outcomes and communicates the results from Earth science missions and research. It also continues the worldwide implementation and U.S. coordination of the Global Learning and Observations to Benefit the Environment (GLOBE) Program, NASA's support for which will be increased as part of the FY 2011 President's budget.

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. The FY 2011 President's budget will support the construction of the pilot for the next generation ground station for this network, development of which has taken place over recent years.

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 sixth 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, including the assessment modeling carried out at the Goddard Institute for Space Studies. The Scientific Computing Project's primary purpose is to support Earth science modeling activities based on data collected by Earth science spacecraft. The FY 2011 President's budget provides increased support for hardware procurement and development of software systems designed to facilitate use of NASA computational hardware for its scientific challenges

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 2011	Program/Project	Changes from FY 2010 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.	None
Competitively selected airborne mission teams.	Tropical photochemistry and Aerosol Airborne Campaign - R&A	None
Competitively selected airborne mission teams.	Hurricane Field Experiment - R&A	None

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates					
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Begin	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-23	
Airborne Science																		Tech Form Dev Ops Res	Jan-90	Dec-23	
Scientific Computing																		Tech Form Dev Ops Res	Jan-95	Dec-23	
HECC																		Tech Form Dev Ops Res	Jan-05 Sep-05	Aug-05 Dec-23	
																			Tech & Adv Concepts (Tech) Formulation (Form) Development (Dev) Operations (Ops) Research (Res) Represents a period of no activity for the Project		

Mission Directorate:	Science
Theme:	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	U.S. Global Change Research Program (USGCRP) participating agencies and Joint Subcommittee on Ocean Science and Technology (JSOST) participating agencies.
Interdisciplinary Science	Earth Science Theme, Science Mission Directorate	Mostly competitive awards	U.S. Global Change Research Program (USGCRP) 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	U.S. Global Change Research Program (USGCRP) 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	U.S. Global Change Research Program (USGCRP) 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	2009	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 2009 meeting, the ESS reviewed and rated the ESD Science Metrics based on the submitted accomplishments and peer-reviewed publications for FY 2009. All six Science Focus Area metrics were rated "green" as documented in the FY 2009 Annual Performance Report (APR).	2010

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	893.7	723.4	809.3	993.9	1,120.8	1,226.8	1,223.5
Global Precipitation Measurement (GPM)	143.8	155.6	128.8	125.7	90.0	52.8	35.7
Glory Mission	61.0	27.1	21.9	5.5	7.7	8.3	8.6
Landsat Data Continuity Mission (LDCM)	200.9	120.6	156.8	157.9	69.5	3.1	3.1
NPOESS Preparatory Project (NPP)	42.2	104.6	64.4	5.2	5.1	5.1	5.4
Ice, Cloud, and land Elevation Satellite (ICESat-II)	38.8	39.2	68.5	116.0	178.6	153.9	94.9
Soil Moisture Active and Passive (SMAP)	103.3	70.0	82.5	139.0	163.8	80.0	10.0
Other Missions and Data Analysis	303.6	206.3	286.5	444.7	606.0	923.6	1,065.9
FY 2010 President's Budget Request	898.9	715.5	725.4	786.4	818.8	867.6	--
Global Precipitation Measurement (GPM)	157.8	159.5	127.6	137.5	111.2	80.4	--
Glory Mission	50.7	27.1	10.1	4.4	1.9	0.0	--
Landsat Data Continuity Mission (LDCM)	200.9	120.6	137.4	165.0	90.0	15.0	--
NPOESS Preparatory Project (NPP)	57.1	112.8	33.8	5.3	5.2	5.1	--
Ice, Cloud, and land Elevation Satellite (ICESat-II)	38.8	39.2	74.6	99.1	126.9	161.7	--
Soil Moisture Active and Passive (SMAP)	104.3	70.0	132.2	180.4	135.0	40.0	--
Decadal Survey Missions	82.3	0.0	10.9	8.8	161.1	374.6	--
Other Missions and Data Analysis	206.9	186.3	198.9	186.0	187.5	190.8	--
Changes from FY 2010 Request	-5.2	7.8	83.9	207.5	302.0	359.1	--

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

Program Overview

The Earth Systematic Missions (ESM) Program (ESMP) is responsible for developing facility (non-Principal Investigator-led) Earth observing research satellite missions; supporting and overseeing the operation of NASA facility research missions once on orbit; and producing standard mission products in support of NASA and national research, applications, and policy communities. In contrast with the PI-led missions in the Earth System Science Program which are generally smaller and have highly focused scientific objectives, Earth Systematic Missions are designed to provide measurements and support for a wide a range of NASA science foci, given programmatic and technical constraints. Ten of the fifteen presently on-orbit research missions for which NASA had development responsibility are operated under ESMP oversight (the US Geological Survey operates Landsat-7, and operational responsibility for OSTM/Jason-2 was transferred to NOAA as planned during FY2009, and the Earth System Science Pathfinder (ESSP) Program manages GRACE, CloudSat and CALIPSO). Four of the five foundational missions presently in development are in the Earth Systematic Mission Program (Glory, NPP, LDCM, and GPM). The Earth Science and Applications Decadal Survey identifies 15 additional systematic NASA research missions which will be developed in the ESMP. Of these Decadal Survey missions, the President's FY11 budget provides funds for developing all four Tier-1 systematic missions (SMAP, ICESAT-2, DESDynI, and CLARREO) for launch by 2017. In consultation with the US Global Change Research Program, NASA will identify and begin development of several Tier-2 Decadal Survey climate missions. Additionally, the President's Budget allows expansion of the ESMP mission portfolio to include the potential development of a SAGE-III instrument on the ISS (2013), the development and launch of a GRACE-FO mission (late 2015 launch), and selected Tier-II Decadal Survey missions.

Interagency and international partnerships play key roles in the ESMP. Seven of the on-orbit missions provide data products in near-real time for use by US and international meteorological agencies and disaster responders. Five of the on-orbit missions involved significant international or interagency collaboration in development, and the 5-satellite A-Train formation-flying constellation (Aqua, CloudSat, CALIPSO, Aura, PARASOL) consists of both NASA and international missions. Two of the four ESMP foundational missions presently in development involve interagency collaboration (NPP, LDCM), while GPM is a joint development between NASA and the Japanese space agency JAXA.

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

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

Plans For FY 2011

The President's budget enables a wide range of significant Earth Systematic Mission Program activities during FY 2011. The foundational systematic missions Glory and NPOESS Preparatory Project (NPP) will launch early and late in the fiscal year, respectively. All four Tier-1 Decadal Survey missions will pursue accelerated implementation activities and milestone reviews targeting launches in early FY 2015 (SMAP), early FY 2016 (ICESat-2), and late CY 2017 (CLARREO, DESDynI). ESMP activities will increase consistent with the expansion of the mission portfolio enabled by the budget, including initiation of the GRACE Follow-on (GRACE FO) mission (FY 2016 launch target) and refurbishment activities to allow the SAGE-III instrument to be ready for flight on the ISS by early CY 2014). Early work will be pursued on selected Tier-2 Decadal Survey and continuity missions identified by NASA and the US Global Change Research Program for accelerated launches in the CY 2017-2020 time frame.

The following specific activities will be undertaken or accomplished in FY 2011:

- Glory will launch (Nov 2010), complete its checkout and scientific validations, and begin routine data acquisition;
- GPM will complete its SIR and KDP-D;
- NPP will complete its satellite pre-ship review and is scheduled to launch (Sep 2011);
- LDCM will complete its spacecraft integration and test, and the Operational Land Imager (OLI) instrument will be delivered to the spacecraft;
- SMAP will complete KDP-C and enter into development;
- ICESat-2 will complete KDP-B and initiate the spacecraft contract;
- DESDynI and CLARREO will enter in Phase A formulation;
- The GRACE FO mission will complete a pre-formulation phase and enter in Phase A formulation;
- The SAGE III instrument will begin refurbishment and will complete ISS accommodation assessment; and
- Production of a dual payload adapter capability for the NASA launch services EELV fleet will be initiated, enabling, among other possibilities, a dual-launch in late CY 2017 of the DESDynI Radar and Lidar spacecrafts.

The regularly scheduled biennial Senior Review of all on-orbit NASA Earth research missions at or soon to be beyond the end of their baseline missions will be conducted during FY 2011.

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

Project Descriptions and Explanation of Changes

Global Precipitation Measurement (GPM) Mission

Extending precipitation measurements beyond the current Tropical Rainfall Measuring Mission (TRMM), the foundational mission GPM will provide detailed, frequent measurements of precipitation including rain rates and droplet size distributions. A joint mission between NASA and JAXA, GPM's two instruments will make valuable direct precipitation measurements and allow precise characterization of many other on-orbit NASA and partner instruments, enabling first-ever, accurate, near-global precipitation maps to be produced. GPM data will contribute to improved operational meteorological predictions as well as to advances in the NASA science focus areas of climate variability and change, water and energy cycles, and weather. Additional GPM information is available under the Development section.

Glory Mission

Glory will provide unique measurements of the global distributions and scattering properties of natural and anthropogenic aerosols, as well as continue the nearly 30-year time series of total solar irradiance measurements. The NASA science focus areas advanced by Glory data 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)

The Landsat Data Continuity Mission (LDCM), a collaboration between NASA and the US Geological Survey, will provide moderate-resolution (15m-120m, depending on spectral frequency) measurements of the Earth's terrestrial and polar regions in the visible, near-infrared, and thermal infrared. LDCM will provide continuity with the 38-year long Landsat land imaging data set. In addition to widespread routine use for water use monitoring, land use planning and monitoring on regional to local scales, and support of disaster response and evaluations, LDCM measurements directly serve NASA research in the Earth surface/interior, and carbon cycle, ecosystems, water cycle, and biogeochemistry focus areas. NASA's LDCM responsibilities include development of the LDCM visible/near-infrared and thermal infrared instruments, provision of the spacecraft and launch vehicle, and design/implementation of the USGS-funded Mission Operations Element. LDCM is being managed to a target December 2012 launch date. Additional LDCM information is available under the Development section.

Mission Directorate:	Science
Theme:	Earth Science
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NPOESS Preparatory Project (NPP)

NPP is a NASA research mission involving a collaboration between NASA, NOAA, and DoD, designed to extend selected scientific data sets initiated by the NASA Earth Observing System and to serve as risk reduction demonstrations for key instruments to be used in the nation's future operational meteorological satellite systems. Owing to delays in development and deployment of the NPOESS system, NPP scheduled to launch in September, 2011, will also serve a critical role to ensure continuity in the nation's operational meteorological measurements from the afternoon orbit. The five instruments on NPP will provide visible and infrared multi-spectral global imagery, measurements of atmospheric temperature and moisture profiles, measurements of total ozone and stratospheric ozone profiles, and measurements of the Earth's radiation balance. In addition to a wide range of applications studies, the NASA 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-2)

ICESat-2, a Tier-1 Decadal Survey mission which entered into formulation in FY 2010 and is being developed for a target launch in late CY 2015, will continue the time series of precision ice topography measurements initiated by ICESAT and extended in selected areas by the ICEBRIDGE campaigns. Time series of land ice topography in particular address a key open issue in climate modeling and prediction, the detailed mechanisms controlling ice sheet dynamics, and how these may change with changing climate. ICESAT-2 measurements of land ice topography, sea ice extent and freeboard, and vegetation canopy height will address a range of NASA science investigations in the areas of cryospheric science; climate variability and change; and carbon cycle, ecosystems, and biogeochemistry. ICESat-2 is the planned follow-on mission to ICESat, measuring elements of ice-sheet mass balance and land surface topography to quantify the contribution to the current and recent sea level changes from changes in the ice quantities, and to establish linkages to climate change. Additional ICESat-2 information is available under the Formulation section.

Soil Moisture Active and Passive (SMAP)

The Soil Moisture Active and Passive (SMAP) mission, Tier-1 Decadal Survey mission, will provide unprecedented global measurements of new information on global soil moisture and land its freeze/thaw state at high latitudes, enabling new advances in hydrospheric science and applications. Direct measurements of soil moisture and freeze/thaw state will be 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. The President's FY 2011 budget accelerates the launch of SMAP into late CY 2014. Additional SMAP information is provided in available under the Formulation section.

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Program:	Earth Systematic Missions

Climate Absolute Radiance and Refractivity Observatory (CLARREO)

The Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission, Tier-1 Decadal Survey mission, is designed to make precision, stable measurements to enable rapid detection of long-term changes in the climate system and its radiation-related feedback mechanisms. The President's FY 2011 budget provides for accelerated development and launch by CY 2017 of a scientifically focused CLARREO spacecraft (one of two planned). In FY 2011 the CLARREO mission will complete its Acquisition Strategy Meeting (ASM) and its System Requirements Review (SRR) and transition to Formulation Phase.

Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI)

The Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI) mission is a Tier-1 Decadal Survey mission which will acquire global measurements using both an L-band Synthetic Aperture Radar (SAR) instrument and a vegetation lidar on separate spacecraft. The President's FY 2011 budget accelerates development of a scientifically and programmatically focused DESDynI mission for a late CY 2017 launch of both spacecraft on a single large EELV launch vehicle. The overall DESDynI radar/lidar mission will greatly advance studies and understanding of climate through measurements of ice sheet velocities and quantification of terrestrial vegetation biomass, of critical importance to closing the global carbon cycle. The mission's interferometric SAR data will be vital to investigation of solid Earth processes and natural hazards such as earthquakes and volcanoes through the observation of accumulated stresses in the solid Earth. DESDynI will enter into formulation at the start of FY 2011 and complete an Acquisition Strategy Meeting during FY 2011.

Stratospheric Aerosol and Gas Experiment (SAGE III) on the ISS

The Stratospheric Aerosol and Gas Experiment (SAGE III) instrument is an existing grating spectrometer that measures ultraviolet/visible energy. In 2009, the SAGE-III instrument was removed from storage and it successfully passed initial aliveness tests. The President's FY 2011 budget provides an opportunity to refurbish and recalibrate the instrument for possible flight on the ISS by late CY 2013. Observing from the International Space Station (ISS) SAGE III will provide near-global, long-term measurements of key components of the Earth's atmosphere. The most important of these are the vertical distribution of aerosols and ozone from the upper troposphere through the stratosphere. In addition, SAGE III will also provide unique stratospheric and mesospheric temperature measurements, of temperature in the stratosphere and mesosphere and profiles of trace gases such as water vapor and nitrogen dioxide that play significant roles in atmospheric radiative and chemical processes. In FY 2011 NASA will complete accommodation studies for the instrument on the ISS.

Gravity Recovery and Climate Experiment - Follow On (GRACE FO)

GRACE, the Gravity Recovery and Climate Experiment, mission launched in March 2002 has acquired precision measurements of the Earth's time-varying gravitational field with a precision that has enabled the measurement of the time variable gravity field, and has led to great discoveries in understanding the Earth system and hold significant keys to climate change research and future climate adaptation. GRACE FO will continue to map the Earth's gravitational field and its monthly variability by making accurate measurements of the distance between the two satellites, using GPS and a microwave ranging system. In FY 2011 the GRACE FO mission will complete its Acquisition Strategy Planning Meeting and its KDP-A transition into Formulation.

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

Other Missions and Data Analysis

Ocean Surface Topography Mission (OSTM) - OSTM 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.

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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 (QuikSCAT) - QuikSCAT measures ocean surface wind vectors using the SeaWinds instrument. QuikSCAT is now five years beyond its design life, and the rotating antenna has stalled due to normal aging of the lubricant and bearings of the spin mechanism. With the antenna stalled, science data can still be collected, but coverage is greatly reduced, severely limiting its operational usage. Research use continues. 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 last remaining laser on ICESat has failed, and the satellite will be decommissioned in FY 2011. 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 and Mission 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 - NASA's Earth Science Division uses Senior Reviews, which are held every two years, to assess the continued science value of missions in operation. These reviews are comprehensive; evaluating the technical status of the satellites, and the value and quality of the data they produce. The Senior Review helps inform decisions related to extending the missions into the future, and the funding level required for each.

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.

Mission Directorate: Science
Theme: Earth Science
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Earth Observation Systems (EOS) Research - The EOS research project funds science for the EOS missions, currently Terra, Aqua, Aura, ICESat and Land Cover missions. These individual-investigator, competitively selected research projects analyze data from the missions to address the related science questions. 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 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 FY 2010 and will be operating in the observational gap between ICESat and ICESat-2.

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.

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.

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. This science team also supports development of mission supporting algorithms for the Global Precipitation Measurement (GPM) mission.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Complete planned operations of currently operating missions.	Operating missions	No change
Launch 2 additional Earth Systematic Mission (ESM) missions.	Glory	Launch in FY 2011
Launch 2 additional Earth Systematic Mission (ESM) missions.	NPP	Launch in FY 2011

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

Implementation Schedule

Project	Schedule by Fiscal Year															Phase Dates																					
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Begin	End																		
Global Precipitation Measurement Mission (GPM)																					Tech				Form	Jul-02	Nov-09	Dev	Dec-09	Jun-13	Ops	Jul-13	Jul-16	Res			
Glory																					Tech				Form	Oct-03	Nov-05	Dev	Nov-05	Nov-10	Ops	Nov-10	Mar-12	Res			
Landsat Data Continuity Mission (LDCM)																					Tech				Form	Oct-03	Nov-09	Dev	Dec-09	Sep-13	Ops	Sep-13	Sep-18	Res			
SMAP																					Tech				Form	Sep-08	Nov-10	Dev	Dec-10	Dec-14	Ops	Jan-15	Jan-18	Res			
ICESat-2																					Tech				Form	Dec-09	Apr-12	Dev	May-12	Jan-16	Ops	Feb-16	Jan-19	Res			
Ocean Surface Topography Mission (OSTM)																					Tech				Form	Dec-02	Mar-06	Dev	Mar-06	Jun-08	Ops	Jul-08	Jul-11	Res			
NPOESS Preparatory Project (NPP)																					Tech				Form	Mar-00	Nov-03	Dev	Dec-03	Sep-11	Ops	Sep-11	Jan-16	Res			
Terra																					Tech				Form			Dev			Ops	Oct-99	Sep-11	Res		Sep-11	
Aqua																					Tech				Form			Dev			Ops	May-02	Sep-11	Res		Sep-11	
Aura																					Tech				Form			Dev			Ops	Jul-04	Jul-10	Res		Jul-12	
Tropical Rainfall Measuring Mission (TRMM)																					Tech				Form			Dev			Ops	Nov-97	Sep-11	Res		Sep-11	
Active Cavity Radiometer Irradiance Monitor Satellite (ACRIMSat)																					Tech				Form			Dev			Ops	Dec-99	Sep-09	Res		Sep-11	
Quick Scatterometer (QuikSCAT)																					Tech				Form			Dev			Ops	Jun-99	Sep-11	Res		Sep-11	

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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

Mission Directorate: Science
Theme: Earth Science
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Program Management

GSFC manages NPP, LDCM, Glory, GPM, Terra, Aqua, Aura, TRMM, EO-1, SORCE, ICESat, and ICESat-2. 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.
SMAP	JPL	JPL/GSFC	TBD
ICESat-2	GSFC	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.

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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.

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

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. The Thermal Infrared Sensor (TIRS) instrument was a directed development, assigned to the GSFC and being built in-house at GSFC.

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 ground system will be selected through open competition.

Senior Reviews are held every two years to assess the continued science value of missions in operation past their prime mission phase. In FY 2009, all operating Earth Systematic Missions other than OSTM went through the competitive Senior Review process to determine whether they should enter or continue in an extended mission phase. Preparations are underway for the 2011 Senior Reviews in which all missions then in operation (currently 13) will be evaluated.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	5/2009	All missions were extended with modifications to their mission budgets.	04/2011

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

FY 2011 Budget Request

Budget Authority (\$ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	<u>300.4</u>	<u>61.0</u>	<u>27.1</u>	<u>21.9</u>	<u>5.5</u>	<u>7.7</u>	<u>8.3</u>	<u>8.6</u>	<u>0.0</u>	<u>440.6</u>
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	70.8
Development / Implementation	229.6	61.0	27.1	21.5	0.0	0.0	0.0	0.0	0.0	339.2
Operations / Close-out	0.0	0.0	0.0	0.4	5.5	7.7	8.3	8.6	0.0	30.5
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
FY 2010 President's Budget Request	<u>300.8</u>	<u>50.7</u>	<u>27.1</u>	<u>10.1</u>	<u>4.4</u>	<u>1.9</u>	<u>0.0</u>	--	<u>0.0</u>	<u>395.0</u>
Formulation	70.8	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	70.8
Development / Implementation	230.0	50.7	15.4	0.0	0.0	0.0	0.0	--	0.0	296.1
Operations / Close-out	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
Changes from FY 2010 Request	<u>-0.4</u>	<u>10.4</u>	<u>0.0</u>	<u>11.8</u>	<u>1.1</u>	<u>5.8</u>	<u>8.3</u>	--	<u>0.0</u>	<u>45.6</u>
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	-0.4	10.3	11.7	21.5	0.0	0.0	0.0	--	0.0	43.1
Operations / Close-out	0.0	0.0	-11.7	-9.7	1.1	5.8	8.3	--	0.0	2.4
Other	0.0	0.1	0.0	0.0	0.0	0.0	0.0	--	0.0	0.1

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

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

Explanation of Project Changes

Cost growth since the FY 2009 Budget is related to the launch delay from January 2010 to November 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.

In spring 2009, an issue with the Maxwell-supplied, spacecraft computer emerged. Late in testing, NASA identified a series of intermittent computer anomalies. Further investigation identified the root cause of the anomalies to be intermittent printed wiring board open circuits. The printed wiring board manufacturer made several unsuccessful attempts to improve the manufacturing process but was unable to develop a reliable, flight quality board. On July 1, 2009, NASA changed the baseline Spacecraft Payload Computer from the Maxwell SCS750 Single Board Computer to the BAE Rad750 Single Board Computer delaying the Glory launch readiness date to November 2010. The key remaining risk to Glory cost and schedule is the readiness of the Taurus XL launch vehicle. On February 24, 2009, NASA's Orbiting Carbon Observatory failed to reach orbit after liftoff from Vandenberg Air Force Base in California, due to a failure of the Taurus XL launch vehicle. NASA convened a Mishap Investigation Board to investigate this incident, and because the Taurus XL is the same launch vehicle that NASA plans to use for Glory, the implementation schedule for corrective actions that addresses the results of this investigation could influence Glory schedule.

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:

- 1) 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.
- 2) 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 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 sixth satellite in the A-Train when it joins the constellation in FY 2011.

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 in El Segundo, California.

The Total Irradiance Monitor (TIM) instrument provides measurement continuity for the 30-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 November 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 2010 PB Request	FY 2011 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	APS: full data processing for 1 yr w/ 2 addtl yrs of archiving. TIM: full data processing for 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 2010 PB Request	FY 2011 PB Request
<i>Development</i>			
Mission Confirmation Review	11/2005	12/2005	12/2005
Mission Pre-ship review	8/2008	1/2009	7/2010
Launch	12/2008	1/2010	11/2010

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

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)
Glory Mission	2008	259.1	2010	339.2	31	Launch Readiness	06/2009	11/2010	17

Development Cost Details

Element	Base Year Development Cost Estimate (\$M)	Current Year Development Cost Estimate (\$M)	Delta
Total:	259.1	339.2	80.1
Aircraft/Spacecraft	31.7	54.8	23.1
Payloads	117.4	126.6	9.2
Systems I&T	3.2	4.0	0.8
Launch Vehicle/Services	55.4	72.1	16.7
Ground Systems	0.9	1.1	0.2
Science/Technology	10.3	14.0	3.7
Other Direct Project Cost	40.2	66.6	26.4

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 planned for January 2010, changing LRD from 6/2009 to November 2010.	01/2010
Performance	NASA HQ	N/A	Flight Operations Review (FOR). This is the 2nd ground system review to examine mission operations requirements, design, testing, and planning is complete	3/2010
Performance	NASA HQ	N/A	Pre-Ship Review (scheduled prior to reserves) - Final review of the satellite readiness prior to shipment to the launch site	07/2010
Performance	NASA HQ	N/A	Mission Readiness Review (MRR) - Final pre-flight review of the operational readiness of the mission	10/2010
Performance	NASA HQ	N/A	Launch Readiness Review (LRR) - Final pre-launch review of the launch vehicle readiness	11/2010

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

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Launch Services Impact of Taurus XL Launch Failure on Glory	If Taurus T-8 (used on Orbiting Carbon Observatory, (OCO) mission) launch failure findings and / or corrective actions impact T-9 (Glory) schedule, then the Glory Launch Readiness Date (LRD) will be impacted	Continue to work with KSC as Taurus Return to Flight plans mature
Spacecraft - Implement Alternate BAE Processor Design in PIP	If Orbital can not execute the late changes to implement the alternate BAE processor design impacts schedule, then the Glory Launch Readiness Date (LRD) will be impacted	Project working closely with Orbital to insure the new spacecraft payload processor is ready on time and within the current reserves posture

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

FY 2011 Budget Request

Budget Authority (\$ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	589.0	42.2	104.6	64.4	5.2	5.1	5.1	5.4	0.4	821.4
Formulation	47.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	47.1
Development / Implementation	541.9	42.2	104.6	58.5	0.0	0.0	0.0	0.0	0.0	747.2
Operations / Close-out	0.0	0.0	0.0	5.9	5.2	5.1	5.1	5.4	0.4	27.1
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	589.0	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	47.7
Development / Implementation	541.3	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	5.0	5.3	5.2	5.1	--	6.0	26.6
Other	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	--	0.0	0.0
Changes from FY 2010 Request	0.0	-14.9	-8.3	30.6	0.0	0.0	0.0	--	-5.6	7.1
Formulation	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	-0.6
Development / Implementation	0.6	-14.9	-8.2	29.7	0.0	0.0	0.0	--	0.0	7.2
Operations / Close-out	0.0	0.0	0.0	0.9	-0.1	-0.1	0.0	--	-5.6	0.5
Other	0.0	0.0	-0.1	0.0	0.1	0.1	0.0	--	0.0	0.0

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Explanation of Project Changes

The changes to the NPP budget are due to the launch delay from January 2011 until September 2011 caused by late delivery to NASA of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument and the Cross-track Infrared Sounder (CrIS) by the NPOESS Integrated Program Office.

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 the National Oceanic and Atmospheric Administration and the U.S. Air Force to extend key environmental measurements for weather prediction and research. The satellite will measure atmospheric and sea surface temperatures, humidity profiles, land and ocean biological productivity, cloud and aerosol properties, and earth radiation budget quantities.

The NPP mission has two objectives: Provide a continuation of select global change observations following the Earth Observing System missions Terra and Aqua, and provide the nation's operational meteorological satellite system with risk-reduction demonstration and validation for critical sensors, algorithms, and ground processing. Due to delays in the development of the NPOESS system, the NPP data will be used operationally to avoid gaps in operational weather data.

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) has been 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 September 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 2010 PB Request	FY 2011 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	Same	Same
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 2010 PB Request	FY 2011 PB Request
<i>Development</i>			
CrIS Flight Model Delivery	Oct 2005	May 2008	June 2010
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	Nov 2009	Dec 2009
CERES Flight Model Delivery	N/A	N/A	Oct 2008
Operations Readiness Review	Jun 2006	Dec 2009	Apr 2011
Launch	Oct 2006	Jan 2011	Sep 2011

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)
NPOESS Preparatory Project (NPP)	2006	592.9	2010	725.2	22	Launch Readiness	04/2008	09/2011	41

Development Cost Details

Element	Base Year Development Cost Estimate (\$M)	Current Year Development Cost Estimate (\$M)	Delta
Total:	592.9	725.2	132.3
Aircraft/Spacecraft	160.0	180.0	20.0
Payloads	194.2	218.2	24.0
Launch Vehicle/Services	72.9	91.4	18.5
Ground Systems	48.2	65.7	17.5
Other Direct Project Cost	117.6	150.0	32.4
Science/Technology	0.0	19.9	19.9

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: CrIs 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	N/A	Operations Readiness Review	4/2011

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Instrument Delivery Delay	If IPO instrument deliveries continue to slip then the NPP LRD will continue to slip; causing increased cost to NPP.	Government program manager worked to successfully execute planned schedule during last year to deliver VIIRS to the NPP project. CrIS instrument repairs in process. Government will work closely with IPO management team to delivery CrIS on plan.

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

FY 2011 Budget Request

Budget Authority (\$ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	<u>205.4</u>	<u>143.8</u>	<u>155.6</u>	<u>128.8</u>	<u>125.7</u>	<u>90.0</u>	<u>52.8</u>	<u>35.7</u>	<u>38.2</u>	<u>975.9</u>
Formulation	205.4	143.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	349.2
Development / Implementation	0.0	0.0	155.6	128.8	125.7	86.9	36.9	15.6	5.7	555.2
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	3.1	15.9	20.1	32.5	71.6
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
FY 2010 President's Budget Request	<u>205.4</u>	<u>157.8</u>	<u>159.5</u>	<u>127.6</u>	<u>137.5</u>	<u>111.2</u>	<u>80.4</u>	<u>--</u>	<u>202.7</u>	<u>1,182.1</u>
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	205.4	157.8	159.5	127.6	137.5	111.2	80.4	--	202.7	1,182.1
Changes from FY 2010 Request	<u>0.0</u>	<u>-14.0</u>	<u>-3.9</u>	<u>1.2</u>	<u>-11.8</u>	<u>-21.2</u>	<u>-27.7</u>	<u>--</u>	<u>-164.5</u>	<u>-206.3</u>
Formulation	205.4	143.8	0.0	0.0	0.0	0.0	0.0	--	0.0	349.2
Development / Implementation	0.0	0.0	155.6	128.8	125.7	86.9	36.9	--	5.7	555.2
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	3.1	15.9	--	32.5	71.6
Other	-205.4	-157.8	-159.5	-127.6	-137.5	-111.2	-80.5	--	-202.7	-1,182.3

Explanation of Project Changes

The changes to the GPM budget are due to the fact that the Low-Inclination Observatory (LIO) implementation approach was changed to an international or domestic partnership for its spacecraft bus and launch vehicle to ensure planned budget/schedule confidence.

Mission Directorate:	Science
Theme:	Earth Science
Program:	Earth Systematic Missions
Project In Development:	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://gpm.gsfc.nasa.gov/>.

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

Project Parameters

The GPM Project includes a Core Observatory Spacecraft and a GPM Microwave Imager (GMI). A second GMI along with a Tracking Data and Relay Satellite System (TDRSS) communication subsystem for near real time data access is planned to be flown on an as yet to be determined (TBD) partner-provided Low-Inclination Observatory (LIO). 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 as yet TBD partner-provided Low-Inclination Observatory is planned to 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. 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 Development: Global Precipitation Measurement (GPM)

Project Commitments

The GPM Core Observatory is planned for a launch in July 2013 to begin a three-year prime mission (five-year goal). The LIO spacecraft, launch vehicle and spacecraft mission operations are planned to be contributed by an as yet to be determined (TBD) partner. The second GMI, flown on the partner-provided LIO, will be available for integration or storage in May 2013. 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 2010 PB Request	FY 2011 PB Request
Core Observatory	GSFC	Provides platform for the GMI and JAXA-supplied DPR instruments	Same	Same
Low-Inclination Observatory	TBD	Provides platform for the second GMI instrument	Same	Changed to be partner-provided
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	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

Schedule Commitments

GPM entered formulation in July 2002. The below milestone dates reflect the December 2009 KDP-C commitments.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
<i>Development</i>			
KDP-C	Dec 2009	May 2009	Dec 2009
Core Observatory launch readiness date (LRD)	Jul 2013	Jun 2013	Jul 2013

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

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)
Global Precipitation Measurement (GPM)	2010	555.2	2010	555.2	0	Launch Readiness	07/2013	07/2013	0

Development Cost Details

Element	Base Year Development Cost Estimate (\$M)	Current Year Development Cost Estimate (\$M)	Delta
Total:	555.2	555.2	0.0
Aircraft/Spacecraft	151.2	151.2	0.0
Payloads	91.2	91.2	0.0
Systems I&T	6.8	6.8	0.0
Launch Vehicles/Services	1.5	1.5	0.0
Ground Systems	30.5	30.5	0.0
Science/Technology	28.4	28.4	0.0
Other direct project cost	245.6	245.6	0.0

Mission Directorate: Science
Theme: Earth Science
Program: Earth Systematic Missions
Project In Development: 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: GMI	GSFC	GSFC	None
Launch vehicle and services: Core Observatory	GSFC	None	JAXA
Launch vehicle and services: Low-Inclination Observatory	TBD	TBD	TBD
Ground Systems	GSFC	GSFC	None

Acquisition Strategy

The GPM instrument was selected through open competition in FY 2005. The Ball Aerospace and Technologies Corporation (BATC) will build the GPM Microwave Imager (GMI) instruments 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's (LIO) Tracking Data and Relay Satellite System (TDRSS) communication subsystem will be acquired by open competition. The LIO spacecraft and launch vehicle are planned to be contributed by ans as yet to be determined partner. The ground systems for both the core spacecraft and the second GMI to be flown on the TBD partner-provided LIO will be selected through open competition.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	HQ and GSFC	12/2009	Mission Critical Design Review (CDR) successfully completed	n/a

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

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 Development: Landsat Data Continuity Mission (LDCM)

FY 2011 Budget Request

Budget Authority (\$ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	<u>221.9</u>	<u>200.9</u>	<u>120.6</u>	<u>156.8</u>	<u>157.9</u>	<u>69.5</u>	<u>3.1</u>	<u>3.1</u>	<u>10.1</u>	<u>943.9</u>
Formulation	221.9	119.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	341.5
Development / Implementation	0.0	81.3	120.6	156.8	157.9	69.0	0.0	0.0	0.0	585.6
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.5	3.1	3.1	10.1	16.8
Other	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	<u>222.0</u>	<u>200.9</u>	<u>120.6</u>	<u>137.4</u>	<u>165.0</u>	<u>90.0</u>	<u>15.0</u>	<u>--</u>	<u>7.1</u>	<u>958.0</u>
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Other	222.0	200.9	120.6	137.4	165.0	90.0	15.0	--	7.1	958.0
Changes from FY 2010 Request	<u>-0.1</u>	<u>0.0</u>	<u>0.0</u>	<u>19.4</u>	<u>-7.1</u>	<u>-20.5</u>	<u>-11.9</u>	<u>--</u>	<u>3.0</u>	<u>-14.1</u>
Formulation	221.9	119.6	0.0	0.0	0.0	0.0	0.0	--	0.0	341.5
Development / Implementation	0.0	81.3	120.6	156.8	157.9	69.0	0.0	--	0.0	585.6
Operations / Close-out	0.0	0.0	0.0	0.0	0.0	0.5	3.1	--	10.1	16.8
Other	-222.0	-200.9	-120.6	-137.4	-165.0	-90.0	-15.0	--	-7.1	-958.0

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Explanation of Project Changes

The LDCM Project, which was approved to proceed with development in December 2009, now has a fully integrated budget including the development and accommodation of the Thermal Infrared Sensor (TIRS). All previous life cycle costs were preliminary estimates.

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

LDCM is being developed 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 Confirmation Review on November 30, 2009, and its KDP-C transition review, on December 16, 2009. Due to the high national importance of the mission and the need to maintain the continuity of the Landsat data record, NASA and USGS will implement the LDCM mission for a December 2012 launch at the 50% schedule confidence level, providing necessary budget and other resources to ensure all mission elements are ready for this launch date. A Joint Confidence Level (JCL) assessment was conducted determining the 70%-confident launch date to be June 2013, driven by the late addition of the TIRS instrument. Specifically, the LDCM Project has been directed to execute all necessary contracts and actions to accomplish the December 2012 Launch Readiness Date, including securing a launch vehicle for a launch in December 2012.

LDCM consists of a two science instruments (the Operational Land Imager and the Thermal Infrared Sensor), a spacecraft, and a mission operations element. The LDCM is in implementation and system level requirements are baselined 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 (visible, NIR, SWIR), 120 meters (thermal); 15 meters (panchromatic).
- 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.

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

Project Commitments

After launch, the spacecraft and OLI instrument will operate for a minimum of five years. The TIRS instrument will operate for a minimum of three years.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 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	Same
Thermal Infrared Sensor (TIRS)	GSFC	Provide Landsat-equivalent thermal data to extend the Landsat data of Earth's land surface for three years.	N/A	New
Spacecraft	General Dynamics	Provide performance and reliability commensurate with OLI and TIRS data requirements.	Same	Same
Launch Vehicle	ULA	Provide launch service access to space.	Same	Same
Mission Operations Element	Hammers Corporation	Provide capability for command and control, mission scheduling, long-term trending and analysis, and flight dynamics analysis.	Same	Same

Schedule Commitments

LDCM will complete its spacecraft Critical Design Review (CDR) and mission CDR in FY 2010. Due to the high national importance of the mission and the need to maintain the continuity of the Landsat data record, NASA and USGS will strive to launch LDCM in December 2012. The LDCM Project has been directed to execute all necessary contracts and actions to accomplish the December 2012 launch. Consistent with NASA policies regarding commitments to cost and schedule, the LDCM launch shall be no later than June 2013.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
<i>Development</i>			
Formulation			
Award OLI contract	July 2007	July 2007	July 2007
Confirmation Review	Dec 2009	Dec 2009	Dec 2009
Critical Design Review (CDR)	Apr 2010	Apr 2010	Apr 2010
PSR	Sep 2012	June 2012	Sep 2012
Launch	Jun 2013	Dec 2012	Jun 2013
Handover of Operations to USGS	Sep 2013	n/a	Sep 2013

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

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)
Landsat Data Continuity Mission (LDCM)	2010	583.4	2010	583.4	0	Launch Readiness	6/2013	6/2013	0

Development Cost Details

Element	Base Year Development Cost Estimate (\$M)	Current Year Development Cost Estimate (\$M)	Delta
Total:	583.4	583.4	0.0
Aircraft/Spacecraft	116.7	116.7	0.0
Payloads	131.3	131.3	0.0
Systems I&T	1.7	1.7	0.0
Launch Vehicle	126.4	126.4	0.0
Ground Systems	10.7	10.7	0.0
Science/Technology	13.3	13.3	0.0
Other Direct Project Costs	183.3	183.3	0.0

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

Project Management

LDCM is under the Earth Systematic Missions Program within the Earth Science Division (ESD) of SMD. The NASA AA is the Decision Authority; the ESD Director is the Responsible Official; and GSFC is the Lead Management Organization.

Project Element	Project Management Responsibility	NASA Center Performers	Cost-Sharing Partners
Operational Land Imager	GSFC	GSFC	None
Thermal Infrared Sensor	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. The Thermal Infrared Sensor will be designed and built in-house at GSFC utilizing civil servants and support contractor personnel.

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	7/2009	Mission Preliminary Design Review - Successful	N/A
Performance	HQ and GSFC	N/A	Mission Critical Design Review	4/2010

Project Risk Management

Title	Risk Statement	Risk Management Approach and Plan
Thermal Infrared Sensor (TIRS) development risk	The TIRS instrument has an aggressive development schedule due to late addition to the instrument complement and there is a risk that TIRS will not be delivered on schedule to meet the LDCM launch readiness date.	The TIRS Project will continuously examine use of parallel paths for instrument development to mitigate risk where appropriate. LDCM Project will develop alternative Observatory I&T scenarios to allow for late arrival of TIRS. In the event that TIRS cannot be delivered in time to meet the LDCM launch date, a flyable mass model will be developed.

Mission Directorate: Science
Theme: Earth Science
Program: Earth Systematic Missions
Project In Formulation: Ice, Cloud, and land Elevation Satellite

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	38.8	39.2	68.5	116.0	178.6	153.9	94.9
FY 2010 President's Budget Request	38.8	39.2	74.6	99.1	126.9	161.7	--
Total Change from 2010 President's Budget Request	0.0	0.0	-6.1	17.0	51.7	-7.8	--

Project Purpose

The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) will continue the measurements begun with the ICESat mission, measuring elements of ice-sheet mass balance, sea ice freeboard and large-scale biomass to quantify polar ice sheet contributions to current and recent sea level change and linkages to the climate state. In addition ICESat-2 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-2 include climate variability and change, Earth surface and interior, and water and energy cycles. The ICESat-2 mission is one of four first-tier missions recommended by the National Research Council (NRC) report entitled, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond". The ICESat-2 mission will draw from the original ICESat satellite launched in FY 2003 and operated through CY 2009.

For more information see <http://nasascience.nasa.gov/missions/icesat-ii>

Project Preliminary Parameters

The ICESat-2 observatory employs a dedicated spacecraft with a multi-beam photon-counting surface elevation lidar. It will be launched into a 600 km, 94-degree, 91-day repeat orbit.

Pursuant to Senate Report 111-34, incorporated by reference into the Statement Accompanying the Consolidated Appropriations Act, 2010 (PL 111-117) and as required by NASA standard project formulation processes, the ICESat-2 Project is working toward a mature [Technology Readiness Level - 6] baseline instrument concept in preparation for formal Mission Confirmation at the end of FY 2012. This includes the photon-counting approach to provide cross-track measurement capabilities identified in Senate Report 111-34. As part of this engineering process, the project will use an airborne instrument to simulate the space-based measurements to optimize the final instrument design and to develop algorithms to meet all Level 1 Requirements. Based on cost and schedule analysis of the ICESat-2 preliminary design, a baseline budget and launch readiness date will be established at Mission Confirmation.

Mission Directorate: Science
Theme: Earth Science
Program: Earth Systematic Missions
Project In Formulation: Ice, Cloud, and land Elevation Satellite

Estimated Project Deliverables

ICESat-2 is still in pre-formulation and does not yet have an official launch date; however, the pre-Phase A target launch date is late 2015 with a notional 5 year prime mission.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	TBD	Competitively selected	New	Same
Lidar Instrument	TBD	Multi-beam micro-pulse laser with photon-counting detector	N/A	New
Launch Vehicle	TBD	Competitively selected	New	Same

Estimated Project Schedule

ICESat-2 is still in pre-formulation. Milestone dates beyond the formulation phase are preliminary estimates pending completion of formulation.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
<i>Formulation</i>			
Formulation			
KDP-A	N/A	September 2009	December 2009
Launch readiness date (LRD)	N/A	Late 2014/Early 2015	Late 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-2 lidar instrument will be designed and tested at GSFC using component procurements from industry. 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 during formulation.

Mission Directorate: Science
Theme: Earth Science
Program: Earth Systematic Missions
Project In Formulation: Ice, Cloud, and land Elevation Satellite

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	ICESat-2 Independent Review Team	02/2009	Mission Concept Review/Requires Delta Review	11/2009
Performance	ICESat-2 Independent Review Team	11/2009	Mission Concept Review /Successfully completed	12/2009
Performance	Standing Review Board	n/a	System Requirements Review (SRR) and Mission Definition Review (MDR)	09/2010

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	103.3	70.0	82.5	139.0	163.8	80.0	10.0
FY 2010 President's Budget Request	104.3	70.0	132.2	180.4	135.0	40.0	--
Total Change from 2010 President's Budget Request	-1.0	0.0	-49.7	-41.4	28.8	40.0	--

Project Purpose

The Soil Moisture Active and Passive (SMAP) mission will provide unique information on global soil moisture and its freeze/thaw states enabling new advances in hydrospheric science/applications and climate research. 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. Obtaining global soil moisture measurements every three days, SMAP's data 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 freeze/thaw information is useful for many purposes, and thus the SMAP mission will contribute to the goals of other Earth Science Focus Areas (Carbon Cycle, Ecosystem, Weather, and Climate). The SMAP mission is one of the four Tier-1 NASA missions recommended by the Earth science and applications Decadal Survey. 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. Climate Initiative funding has been used to advance the SMAP launch date by 7 months to late CY 2014.

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 CY 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 2010 PB Request	FY 2011 PB Request
Spacecraft	JPL	Provides platform for the instrument	New	Same
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	New	Same
L-Band Radiometer	GSFC	Combined with SAR provides soil moisture measurements in the top 5 cm of soil through moderate vegetation cover	New	Same
Launch Vehicle	TBD	TBD	New	Same

Estimated Project Schedule

With the Climate Initiative provided in the President's FY2011 budget, SMAP launch has been accelerated at least 7 months, from mid CY 2015 to late CY 2014. This launch date cannot be further accelerated by additional funding augmentations; it is dictated by launch vehicle selection and implementation process times, and by the minimum SMAP Phase C-D durations recommended by the Project's Independent Standing Review Board. SMAP will conduct a three-year prime mission.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
<i>Formulation</i>			
Formulation			
KDP-C	April 2010	December 2010	December 2010
Launch readiness date (LRD)	Mid CY 2015		late CY 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	02/2009	Mission Design Review-successfully completed.	05/2009

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	122.1	80.0	303.8	204.3	196.4	190.1	228.9
Aquarius	46.9	18.3	17.0	5.4	5.2	2.4	4.6
OCO-2	0.0	25.0	171.0	91.0	51.0	13.0	4.0
Venture Class Missions	21.0	12.9	79.5	75.1	106.9	140.5	185.3
Other Missions and Data Analysis	54.3	23.8	36.2	32.7	33.4	34.2	35.0
FY 2010 President's Budget Request	118.3	63.9	128.8	114.2	121.4	119.1	--
Aquarius	44.7	18.3	6.3	4.2	2.8	0.0	--
Venture Class Missions	21.0	12.9	79.2	66.5	75.1	75.7	--
Other Missions and Data Analysis	52.6	32.8	43.3	43.5	43.5	43.4	--
Changes from FY 2010 Request	3.9	16.1	175.0	90.0	75.0	71.0	--

Program Overview

ESSP includes a series of relatively low-to-moderate cost, small-to-medium sized, competitively selected, Principal Investigator-led missions. These missions, complement the larger and more broadly capable Earth Systematic Missions (ESM). ESSP missions each have focused scientific objectives to support a selected subset of studies of the atmosphere, oceans, land surface, polar ice regions, or solid Earth. Investigations include development and operation of remote-sensing instruments and the conduct of investigations using data from these instruments. In FY 2011, NASA will initiate the accelerated development of an Orbiting Carbon Observatory Reflight mission (OCO-2) with the objective to launch in Feb 2013. In mid-FY 2010, the awards will be made for the initial Venture Class solicitation (EV-1). The selectees will commence their airborne campaign study activities in FY 2011. The ESSP will complete the development two solicitations: (1) the second Earth Venture AO call, EV-2, to be released in FY 2012 for small complete satellite missions, and (2) the initial annual call (EV-Instrument) for instruments of opportunity in support of the Climate Initiative. The initial EV-Instrument call will be released at the start of FY 2012 for an anticipated instrument delivery in FY 2015; annual EV-Instrument calls are an integral part of the Climate Initiative and are supported in the President's budget. ESSP currently has one mission in formulation (OCO-2), 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).

For more information see <http://earth.nasa.gov>

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

Plans For FY 2011

The Earth System Science Pathfinder (ESSP) Program plans for FY 2011 include:

- 1) Completion of Aquarius/SAC-D observatory environmental testing, delivery to the launch site, launch and on-orbit checkout of the Aquarius/SAC-D mission;
- 2) Completion of the OCO-2 KDP-C and transition of this mission into development;
- 3) Initial science data acquisitions from the selected EV-1 investigations;
- 4) Preparation and release of the EV-2 small-mission AO, with selections to take place in FY 2012;
- 5) Preparation (for an early 2012 release) of the first annual EV-Instrument AO, soliciting significant Earth-observing instruments for flights of opportunity;
- 6) Continued operations of GRACE, CloudSat, and CALIPSO will continue operations as determined by the 2009 Senior Review; and,
- 7) Conduct and completion of the 2011 biannual Senior Review for GRACE, Cloudsat, and CALIPSO.

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

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 manifested launch date of January 2011 and 3 years of prime mission life. Additional detail can be found in the Aquarius development section of this document.

Orbiting Carbon Observatory - 2

OCO-2 is a replacement for the original OCO, which failed to reach orbit in February 2009 due to a launch vehicle anomaly. OCO-2 will utilize OCO's implementation approach to the greatest degree practical to reduce mission development risk. The OCO-2 mission objectives are identical to those for OCO. The OCO-2 employs a dedicated spacecraft with a single instrument, designed to measure CO₂ and O₂ near-infrared absorptions from reflected sunlight. Additional detail can be found in the OCO-2 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 FY 2002, measures Earth's gravity field and its variations with time.
- CloudSat, launched in FY 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 FY 2006, measures the vertical distribution of clouds and aerosols in the atmosphere.

In addition, this line includes the ESSP research project providing funds for the 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 2011	Program/Project	Changes from FY 2010 PB Request
Senior Review (SR) to make Senior recommendations on mission extensions	GRACE, CloudSat, and CALIPSO	Same

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

Implementation Schedule

Project	Schedule by Fiscal Year														Phase Dates							
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End			
Aquarius																				Tech		
																				Form	Oct-03	Sep-05
																				Dev	Oct-05	Jan-11
																				Ops	Jan-11	Apr-14
																				Res		
Orbiting Carbon Observatory - 2																				Tech		
																				Form	Feb-10	Sep-10
																				Dev	Oct-10	Jan-13
																				Ops	Feb-13	Feb-15
																				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	Sep-11
																				Res		
																				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.
Orbiting Carbon Observatory - 2	JPL	JPL	N/A
Gravity Recovery and Climate Experiment (GRACE)	Earth Science Division	JPL	Deutsches 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.

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 2011 winners of the first Venture Call, EV-1, will begin their airborne campaign mission development activities.

Preparations will be completed for the second Venture Class call, EV-2, and for the first release of the instrument only AO, EV-11, with the AOs for each to be released in FY 2012. OCO-2 is a NASA directed mission, but remains under the ESSP Program, as the original OCO was selected under an AO. NASA will seek to duplicate the OCO acquisition strategy to the greatest degree practical.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Quality	Senior Review Panel	05/2009	CALIPSO, GRACE and CloudSat were reviewed as part of the Earth Science biennial Senior Review process. All three missions were approved for extended operations through the end of FY11.	04/2011
Performance	SRB	N/A	OCO-2 will be subject to a KDP-C Confirmation Review to establish the mission development baseline	11/2010

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

FY 2011 Budget Request

Budget Authority (\$ millions)	Prior	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	BTC	LCC TOTAL
FY 2011 President's Budget Request	<u>181.6</u>	<u>46.9</u>	<u>18.3</u>	<u>17.0</u>	<u>5.4</u>	<u>5.2</u>	<u>2.4</u>	<u>4.6</u>	<u>4.8</u>	<u>286.2</u>
Formulation	35.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.6
Development / Implementation	146.0	46.9	18.3	13.7	0.0	0.0	0.0	0.0	0.0	224.9
Operations / Close-out	0.0	0.0	0.0	3.3	5.4	5.2	2.4	4.6	4.8	25.7
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FY 2010 President's Budget Request	<u>181.5</u>	<u>44.7</u>	<u>18.3</u>	<u>6.3</u>	<u>4.2</u>	<u>2.8</u>	<u>0.0</u>	--	<u>0.0</u>	<u>257.8</u>
Formulation	35.6	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	35.6
Development / Implementation	145.9	44.7	15.8	0.0	0.0	0.0	0.0	--	0.0	206.4
Operations / Close-out	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
Changes from FY 2010 Request	<u>0.1</u>	<u>2.2</u>	<u>0.0</u>	<u>10.7</u>	<u>1.2</u>	<u>2.4</u>	<u>2.4</u>	--	<u>4.8</u>	<u>28.4</u>
Formulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--
Development / Implementation	0.1	2.2	2.5	13.7	0.0	0.0	0.0	--	0.0	18.5
Operations / Close-out	0.0	0.0	-2.5	-3.0	1.2	2.4	2.4	--	4.8	9.9
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	--

Note: The FY 2011 LCC number does not reflect the difference between the FY 2010 enacted and the FY 2010 initial operating plan. Any adjustments to the LCC will be included in the FY 2010 initial operating plan.

Explanation of Project Changes

The FY 2010 Budget for Aquarius reflected the cost for a launch in May 2010. Spacecraft development delays at NASA's foreign partner, Argentina's National Committee of Space Activities (CONAE) spacecraft have delayed the launch to no earlier than December 2010, with a current manifest date of January 2011. The current budget reflects this change.

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 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 is manifested to launch in January 2011 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 2010 PB Request	FY 2011 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. In December 2009, the NASA Science Mission Directorate Program Management Council approved another rebaseline of Aquarius, including a launch delay manifesting the Aquarius/SAC-D mission for a January 2011 launch.

Milestone Name	Confirmation Baseline	FY 2010 PB Request	FY 2011 PB Request
<i>Development</i>			
Mission Confirmation Review	September 2005	September 2005	September 2005
Mission CDR	August 2007	July 2008	July 2008
Aquarius Instrument Pre-ship Review [FY 2008 APG]	May 2008	May 2009	May 2009
Launch	March 2009	May 2010	January 2011

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	2010	222.6	16	Launch Readiness	07/2009	01/2011	18

Development Cost Details

Element	Base Year Development Cost Estimate (\$M)	Current Year Development Cost Estimate (\$M)	Delta
Total:	192.6	222.6	30.0
Payloads	55.4	96.1	40.7
Launch Vehicle/Services	78.9	79.4	0.5
Ground Systems	5.5	5.5	0.0
Science/Technology	10.9	11.8	0.9
Other Direct Project Cost	41.9	29.8	-12.1

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	4/2009	Aquarius/SAC-D Systems Integration Review -- Determined readiness of Aquarius instrument integration with the SAC-D Observatory (Phase D). Recommendation to proceed to Phase D.	7/2010
Performance	Aquarius Standing Review Board	11/2009	Aquarius Rebaseline Review -- Determined readiness of Aquarius instrument integration with the SAC-D Observatory (Phase D). Recommendation to proceed to Phase D.	7/2010

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.

Mission Directorate: Science
Theme: Earth Science
Program: Earth System Science Pathfinder
Project In Formulation: OCO - 2

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	0.0	25.0	171.0	91.0	51.0	13.0	4.0
Total Change from 2010 President's Budget Request	0.0	25.0	171.0	91.0	51.0	13.0	--

Project Purpose

The data received from the Orbiting Carbon Observatory-2 (OCO-2) will support climate research by providing an improved understanding of natural, distributed CO₂ sources and sinks and ocean/atmosphere and land/atmosphere CO₂ exchange processes. OCO-2 measurements will initiate a global time series of atmospheric CO₂ for direct support of policy development and verification of regulations and environmental treaties. Rapid development and launch of OCO-2 is a key element of the President's budget.

OCO-2 replaces the original OCO, which failed to reach orbit in February 2009 due to a launch vehicle anomaly. OCO-2 will utilize OCO's detailed design and implementation approach to the greatest possible degree to reduce risk. The mission objectives of OCO and OCO-2 are identical.

Project Preliminary Parameters

The OCO-2 mission consists of a dedicated spacecraft with a single instrument, flying in a near-polar, sun synchronous orbit launched by an expendable launch vehicle. The orbit's early afternoon equator crossing time maximizes the available signal and minimizes diurnal biases in CO₂ measurements associated with photosynthesis. The OCO-2 flight system uses hardware components, software and processes with spaceflight heritage. OCO-2's three-axis stabilized bus design is derived from the LEOStar-2 spacecraft class currently in production at Orbital Science Corporation. The design and architecture of the OCO-2 spacecraft bus is based on the successful Solar Radiation and Climate Experiment (SORCE) and Galaxy Explorer (GALEX) missions. The spacecraft structure is made of honeycomb panels that form a hexagonal shape. This structure houses the instrument and the spacecraft bus components. Panels with solar cells are attached and stowed such that the whole structure fits inside the small fairing of the Taurus XL launch vehicle. For the OCO-2 mission, the spacecraft has been elongated to accommodate the instrument and the instrument has been embedded into the structure of the spacecraft. The instrument consists of a single telescope feeding three high-resolution grating spectrometers. The optics will be cooled to approximately 270 Kelvin and the Focal Plane Arrays (FPAs) to approximately 120 Kelvin. The instrument is designed to measure CO₂ and O₂ near-infrared absorptions from reflected sunlight. Remote sensing retrieval algorithms will process these data to yield estimates of the column-averaged CO₂ dry air mole fraction, XCO₂. The total weight of the observatory is about 530 kilograms (1170 pounds). The original OCO successfully completed qualification of this configuration prior to launch.

Mission Directorate: Science
Theme: Earth Science
Program: Earth System Science Pathfinder
Project In Formulation: OCO - 2

Estimated Project Deliverables

The OCO-2 is planned to launch in February 2013 to begin a two-year mission. OCO-2 will provide atmospheric CO2 measurements with near global coverage of the sunlit portion of the Earth with a 16-day repeat cycle.

Project Element	Provider	Description	FY 2010 PB Request	FY 2011 PB Request
Spacecraft	Orbital Sciences Corp	Provides platform for the instrument	N/A	New
OCO-2 Instrument	JPL	Three channel, high-resolution grating spectrometer measuring CO2 and O2 near-infrared absorptions from reflected sunlight	N/A	New
Launch Vehicle	Orbital Sciences Corp	Taurus XL	N/A	New

Estimated Project Schedule

Based on the design maturity, (due to the heritage of OCO), OCO-2 will be placed in Formulation in February 2010. Completion of KDP-C and transition to Development is expected in late CY2010. Further milestone dates are preliminary estimates pending completion of Formulation and KDP-C.

Milestone Name	Formulation Agreement Estimate	FY 2010 PB Request	FY 2011 PB Request
<i>Formulation</i>			
KDP-C	N/A	N/A	December 2010
Launch readiness date (LRD)	N/A	N/A	February 2013

Mission Directorate: Science
Theme: Earth Science
Program: Earth System Science Pathfinder
Project In Formulation: OCO - 2

Project Management

The Jet Propulsion Laboratory (JPL) has project management responsibility for OCO-2. 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	None	None
Instrument	JPL	JPL	None
Ground System	JPL	JPL	None
Launch Vehicle	JPL	KSC	None

Acquisition Strategy

The OCO-2 Spacecraft will be built by Orbital Sciences Corporation. A sole source procurement is being pursued to maintain the same configuration as OCO. The OCO-2 instrument will be built in-house at JPL.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Performance	OCO-2 SRB	N/A	OCO-2 will complete a KDP-C Confirmation Review, to establish the mission development baseline.	11/2010

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	146.0	149.9	161.2	164.5	160.5	165.8	169.8
Earth Science Multi-Mission Operations	146.0	149.9	161.2	164.5	160.5	165.8	169.8
FY 2010 President's Budget Request	148.1	149.9	160.3	165.4	161.3	165.5	--
Earth Science Multi-Mission Operations	148.1	149.9	160.3	165.4	161.3	165.5	--
Changes from FY 2010 Request	-2.1	0.0	0.9	-0.9	-0.8	0.3	--

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 successful completion of the Evolution of EOSDIS Elements (EEE) effort has increased efficiency and operability; increased data usability by the research, application, and modeling communities. EOSDIS is now 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 budget request for FY 2011 incorporates cost savings that result from this effort. A system plan for 2015 and beyond will guide further improvements and will take into account evolution needs for new missions being developed in response to the decadal survey Earth Science and Applications from Space (National Research Council). 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 2011

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.

NASA plans to continue the support of the Evolution of EOSDIS Elements effort to enable a service oriented architecture between now and 2015.

Five-year MEaSURES Projects began work in FY 2008 to continue NASA support of the development of multi-instrument Earth System Data Records, including Climate Data Records. An Advanced Collaborative Connections for Earth System Science (ACCESS) solicitation was released in NASA's Research Opportunities in Space and Earth Sciences - 2009 (ROSES-2009) and selections were made for new ACCESS Projects beginning in FY 2010. A third program solicitation, Earth System Data Records Uncertainty, is being readied for ROSES-2010. 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.

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

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.

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 FY 2013.

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

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.

Program Commitments

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

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

Implementation Schedule

Project	Schedule by Fiscal Year														Phase Dates															
	Prior	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23		Beg	End											
EOSDIS and Multi-Mission Operations (including DAACs)																														
Elements of EOSDIS Evolution (phased start-up beginning in FY 2008)																														
<table border="0"> <tr> <td style="background-color: #cccccc; width: 20px;"></td> <td>Tech & Adv Concepts (Tech)</td> </tr> <tr> <td style="background-color: #999999; width: 20px;"></td> <td>Formulation (Form)</td> </tr> <tr> <td style="background-color: #cccccc; width: 20px;"></td> <td>Development (Dev)</td> </tr> <tr> <td style="background-color: #333333; width: 20px;"></td> <td>Operations (Ops)</td> </tr> <tr> <td style="background-color: #666666; width: 20px;"></td> <td>Research (Res)</td> </tr> <tr> <td style="background-color: #ffffff; width: 20px;"></td> <td>Represents a period of no activity for the Project</td> </tr> </table>																				Tech & Adv Concepts (Tech)		Formulation (Form)		Development (Dev)		Operations (Ops)		Research (Res)		Represents a period of no activity for the Project
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	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, Earth System Data Records Uncertainty Analysis (peer-reviewed data research)	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, is being recompeted to be completed in 2010.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Other	Earth Science Subcommittee	10/2009	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	ongoing	DAAC archive holdings peer reviewed for scientific merit. Multiple reviews related to individual research areas, all successful, several recommendations in work.	annual

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	55.3	45.9	52.8	53.9	57.1	64.7	68.0
Earth Science Technology	55.3	45.9	52.8	53.9	57.1	64.7	68.0
FY 2010 President's Budget Request	54.1	45.9	47.2	48.2	49.5	52.7	--
Earth Science Technology	54.1	45.9	47.2	48.2	49.5	52.7	--
Changes from FY 2010 Request	1.2	0.0	5.6	5.7	7.7	11.9	--

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 2011

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 FY 2011 new work will be solicited in the Advanced Information Systems Technology and Advanced Component Technology areas. This FY 2011 solicitation will be part of the ROSES-2011 NASA Research Announcement. Both calls will support the expanded and accelerated mission set enabled by the President's budget including the Climate Initiative.

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

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 FY 2007 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 FY 2008 and will continue through FY 2011. The next solicitation was released in FY 2010 with selections expected to be made in the first quarter of FY 2011.

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. The next solicitation is in the ROSES-11 with selections expected to be made in the first quarter of FY 2012.

The last solicitation released in June 2008 awarded 20 additional projects in early FY 2009, 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 deployed 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.

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

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. The next solicitation is in ROSES-11 with selections expected to be made in the first quarter of FY 2012.

The last solicitation for Advanced Component Technology was in ROSES-08 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 2011	Program/Project	Changes from FY 2010 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 technology 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, MSFC	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 - Earth Science Sub Committee	10/2009	The Earth Science Subcommittee reviewed the Earth Science Technology Program for infusion of new technologies and participation of universities in developing the new generation of technologists. The committee was overall pleased with the technology program; it wanted to ensure that tasks focus on being able to reduce cost in missions and are directed towards enabling/enhancing specific measurements.	10/2011

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

FY 2011 Budget Request

Budget Authority (\$ millions)	FY 2009 Actual	FY 2010 Enacted	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015
FY 2011 President's Budget Request	47.8	32.2	36.6	38.3	41.1	45.9	48.7
Pathways	47.8	32.2	36.6	38.3	41.1	45.9	48.7
FY 2010 President's Budget Request	47.8	32.2	30.7	31.5	32.2	33.1	--
Pathways	47.8	32.2	30.7	31.5	32.2	33.1	--
Changes from FY 2010 Request	0.0	0.0	5.9	6.9	8.9	12.8	--

Program Overview

The Applied Sciences Program (<http://nasascience.nasa.gov/earth-science/applied-sciences>) leverages NASA Earth Science research and observations to enable innovative and practical uses in management, business, and policy decisions. NASA Applied Sciences projects address applied research needs in the user community, discover and demonstrate new applications of Earth science data, and facilitate adoption of applications by non-NASA stakeholder organizations. The projects are designed to improve decision-making activities through which the nation can better manage its resources, improve quality of life, 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 infectious diseases with the Centers 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 air quality management; improving the Department of Agriculture's Global Economic Forecasting; and international disaster management support with the U.S. Agency for International Development. The Program's primary outcomes are the routine, sustained uses of NASA Earth science products in user organizations' policy, business, and management decisions to serve society; the impacts are the resulting socioeconomic benefits from the improved decisions.

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

Plans For FY 2011

In FY 2011, the Applied Sciences Program will continue or initiate projects across a range of application areas, including agriculture, air quality, climate, ecological forecasting, public health, natural disasters, water resources, and weather. These projects are competitively selected through NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2007, 2008, 2009, and 2010. In FY 2011, the Program will feature increased joint solicitations with research and end-user organizations, expanded contributions to mission science teams to ensure consideration and incorporation of applications requirements throughout the mission design process, and continuation of efforts to build skills and capabilities on how to access and apply Earth observations data to benefit society. The FY 2011 President's Budget enables the Program to introduce a new solicitation, increase the number of project selections, increase end-user involvement in early phase mission planning, and expand the products and services provided by the highly successful NASA/USAID joint-funded SERVIR network.

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

Project Descriptions and Explanation of Changes

Applied Sciences

In FY 2011, the Applied Sciences Program will sponsor several solicitations and competitively-selected projects across the range of applications themes described above, including topics that cross-cut these themes:

1. Decision Support projects: These are 3-4 year projects that are carried out collaboratively with end user organizations to integrate Earth observations data into their decision-making activities and enable the transition for the organizations' sustained use of the Earth observations data.
2. Applications Feasibility projects; These are short-term, proof-of-concept projects to generate and test preliminary ideas for applications of Earth science products to determine their potential value and readiness for a more in-depth project.
3. Applications Knowledge projects: These are multiple-year projects focused on applied research to generate fundamental understanding of how Earth science can be scaled and applied to serve society and methods to enable institutions to apply new types of information in traditional decision making activities.
4. Applied Sciences Teams: These are multiple-year teams of applications-specialists and scientists to address key applications-oriented challenges and critical data products needed by the applied community and end users.

The program supports joint solicitations with the Earth Science Research Program and supports some applications-oriented projects that are identified in solicitations managed by the Research Program's science focus areas.

The projects also include a small number of activities that crosscut and support the tasks, including capacity building projects, workshops, and outreach activities.

In FY11, the Applied Sciences Program will expand the SERVIR network and enhance its scientific capabilities across a broader set of NASA Earth science products and its service as a testbed for innovative applications.

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

Performance Evaluation

As part of the Administration's government-wide initiative to strengthen program evaluation, the request includes funds for a study of the NASA Earth Science's Applied Sciences Program (hereafter, the Program). NASA's current evaluation efforts are focused primarily on large engineering projects. NASA seeks to develop capacity to perform appropriate impact evaluations for small, science-based projects that have the potential to provide direct societal benefits stemming from NASA research investments. The Program works with numerous partner organizations (e.g., FAA, EPA, CDC, USFS, USAID) which have different types of management and decision activities (e.g., resource allocation, early warning, forecasting, planning, response and recovery), with their organization's corresponding outcome and impact measures. The Program develops applications and facilitates their transition and adoption by the partner organizations. As such, the Program would also benefit from factors within the impact evaluations that can help to highlight key success criteria across the decision types.

This study will select 2 projects completed in the 2009-10 timeframe, addressing two different application topics, in order to pilot evaluation approaches for different types of decision making. The study will likely use a pre-post comparison to assess utility, efficiency, and/or effectiveness gains in the partners' decision making. The evaluation will compare the improved decision-making performance (with NASA data) compared to baseline conditions (without NASA data). The evaluations will pilot an approach to conduct a value-of-information or cost-benefit analysis on the completed projects. The information and capabilities from this pilot effort can help NASA in further studies to identify critical factors in the design and execution of applications projects, and to scope larger-scale activities in determining and articulating impacts of its science and other research-based programs.

This study is one of 23 evaluation proposals specifically approved by the Office of Management and Budget for 2011 to strengthen the quality and rigor of Federal program evaluation. To ensure the study is well designed and implemented, NASA will work with evaluation experts at OMB and the Council of Economic Advisers during the planning, design, and implementation of the study. NASA is committed to promoting strong, independent evaluation that can inform policy and program management decisions and will post the status and findings of this and other important evaluations publicly available online.

Program Commitments

Commitment/Output FY 2011	Program/Project	Changes from FY 2010 PB Request
Issue competed peer reviewed research awards.	Applied Sciences	Same
Maximize resource utilization through streamlining processes and operations across the program.	Applied Sciences	Same
Conduct impact evaluation on mature projects.	Applied Sciences	New

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

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 Western Governors Association, American Water Resources Association, Gulf of Mexico Alliance. Private sector and universities. Non-Profit and intergovernment organizations, such as United Nations Food and Agriculture Organization.

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. The program emphasizes cost-sharing in projects, especially Decision Support projects.

Independent Reviews

Review Type	Performer	Last Review	Purpose/Outcome	Next Review
Relevance	National Research Council	10/2007	The Applied Sciences Program strategy and implementation.	2013
Relevance	Applied Sciences Analysis Group	N/A	Applied Sciences program strategy and implementation.	12/2010

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