National Aeronautics and Space Administration

Fiscal Year 2011

# Performance & Accountability Report

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# NASA's Performance and Accountability Report

The National Aeronautics and Space Administration (NASA) produces an annual Performance and Accountability Report (PAR) to share the Agency's progress toward achieving its Strategic Goals with the American people. In addition to performance information, the PAR also presents the Agency's financial statements as well as NASA's management challenges and the plans and efforts to overcome them.

NASA's Fiscal Year (FY) 2011 PAR satisfies many U.S. government reporting requirements, including the Government Performance and Results Act Modernization Act of 2010, the Chief Financial Officers Act of 1990, and the Federal Financial Management Improvement Act of 1996.

NASA's FY 2010 PAR contains the following sections:

## Management's Discussion and Analysis

The Management's Discussion and Analysis (MD&A) section (see page 1) highlights NASA's overall performance; including programmatic, financial, and management activities. The MD&A includes a description of NASA's organizational structure and describes the Agency's performance management system and management controls (i.e., values, policies, and procedures) that help program and financial managers achieve results and safeguard the integrity of NASA's programs.

## Detailed Performance

The Detailed Performance section (see page 39) provides more in-depth information on NASA's progress toward achieving milestones and goals as defined in the Agency's 2011 Strategic Plan and NASA's FY 2011 Performance Plan. It also includes plans for correcting performance measures that NASA did not achieve in FY 2011 and an update on the measures that NASA did not complete in FY 2010.

## Financials

The Financials section (see page 187) includes the Agency's financial statements, the audit results submitted by independent accountants in accordance with government auditing standards, and the Agency's response to the audit findings.

## Other Accompanying Information

The Other Accompanying Information (OAI) section (see page 245) includes the Inspector General's statement on NASA's management and performance challenges, the status of the Agency's follow-up actions on the Inspector General's audits, an Improper Payments Information Act assessment, a summary of the financial statement audit and management assurances, and NASA's Missions at a Glance, which provides more details about NASA flight missions mentioned in the PAR.

NASA's PAR is produced by the Office of the Chief Financial Officer's Strategic Investments Division, with contract support by The Tauri Group. If you have questions about NASA's PAR, please e-mail hq-dl-parteam@mail.nasa.gov.

This document is available online at http://www.nasa.gov/news/budget/index.html.

**Errata:** NASA made corrections to the document in April 2012 as follows:

Page 195: The fiscal years ended month for the Combined Statement of Budgetary Resources was changed from "June" to "September."

Pages 226, 228, and 230: "(audited)" was removed from after the fiscal year for the Required Supplementary Stewardship Information and Required Supplementary Information.

Cover photo: *Atlantis*' chute slows the Space Shuttle on the runway at Kennedy Space Center, bringing the last Shuttle mission—STS-135—to a successful close. Onboard are STS-135 Commander Chris Ferguson, Pilot Doug Hurley, and Mission Specialists Sandra Magnus and Rex Walheim. (Credit: NASA/K. Allen)

# Message from the Administrator

November 15, 2011

I am pleased to present NASA's fiscal year (FY) 2011 Performance and Accountability Report (PAR). This report allows us to share our FY 2011 successes and setbacks with the American people as we strive to achieve our Mission. The performance and financial information in the PAR also provides valuable insight into our stewardship of taxpayer dollars and the resources entrusted to NASA.

FY 2011 was a year of remarkable change for NASA. As we closed the door on 30 years of Space Shuttle flights, we opened the door to a new era of exploration and took our critical first steps on that path. We unveiled a new Strategic Plan with NASA's new Vision and long-term goals to guide our activities and priorities over the next decade while continuing our commitment to NASA's core values of Safety, Integrity, Teamwork, and Excellence.

This year, we turned a page in space exploration history as we said a heartfelt farewell to the Space Shuttle. Between the first launch on April 12, 1981, and the final landing on July 21, 2011, NASA's Space Shuttle fleet—*Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavour*—flew 135 missions, helped construct the International Space Station (ISS), and inspired generations. The orbiters *Discovery*, *Atlantis*, and *Endeavour* are undergoing preparations to be delivered to museums across the country, where they will continue to inspire the next generation of explorers and remind us of what the vision and dedication of a Nation can accomplish.

Retiring the most recognizable icon of U.S. space exploration was not an easy decision, but it was the right one. The time has come for us to set our sights on a new era of exploration. We are stimulating efforts within the private sector and paving the way for a robust U.S. commercial capability to take both crew and cargo safely to the ISS and low Earth orbit. Our commercial partners are making substantial progress as evidenced by the successful orbital test of the Dragon capsule on the Falcon 9 rocket in December 2010, which is a key milestone toward the spacecraft rendezvousing with the ISS in the next year.

While the commercial sector is focused on low Earth orbit access, we have set our sights on a new space exploration system that will take humans far beyond Earth. In September 2011, we selected the design for this new space exploration system—a heavy-lift rocket that will be America's most powerful since the Saturn V rocket that carried Apollo astronauts to the Moon. The Space Launch System (SLS) will be able to launch humans to asteroids, Mars, and other deep space destinations. This critical design decision will create jobs here at home and provide the cornerstone for America's future human space exploration efforts.

Space exploration is not just about innovation and discovery, it is a story of perseverance. Often, it takes years to watch a project come to fruition—but the rewards are well worth the wait. NASA's scientific discoveries just keep coming and coming, based on that perseverance. In September 2007, we launched the Dawn spacecraft to the asteroid belt between Mars and Jupiter to learn more about the two largest asteroids, Vesta and Ceres, after more than five years since Dawn was selected as a mission. In July 2011, after a journey of more than a billion miles, and more than three and a half years, Dawn achieved orbit around Vesta. With a diameter of 330 miles (530 kilometers), Vesta is the second most massive object in the asteroid belt, second only to Ceres. Dawn will orbit Vesta for a year before moving on to Ceres. Dawn's science instruments will measure surface composition, topography, and texture. Dawn will also measure the tug of gravity from Vesta and Ceres to learn more about their internal structures. Studying these two giant asteroids will not only help scientists unlock the secrets of our solar system's early history, but it will also provide us with valuable information for the future exploration of these bodies and greater insight into how we might address any asteroids that pose a threat to Earth.

We are proud of the progress we made this year. You will find highlights of our programmatic and fiscal activities in the Management's Discussion and Analysis section of this report. However, I encourage you to read the Detailed Performance section to learn more about our successes and setbacks. For the setbacks, you will find detailed information on the causes and what we plan to do to get back on track. I also encourage you to peruse the Financials section of this report, to get a better understanding of how we are managing our resources—your tax dollars. Included in that section are letters and reports from our external auditors and our Inspector General that speak to our progress.

NASA makes every effort to ensure that performance data are subject to the same attention to detail as is devoted to our scientific and technical research. With this in mind, I can provide reasonable assurance that the performance data in this report are reliable and complete. Any data limitations are documented explicitly in the report.

In addition, NASA accepts the responsibility of accounting for and reporting on its financial activities. During FY 2011, NASA received an unqualified "clean" opinion on its financial statements. This significant achievement resulted from the efforts of dedicated personnel across the Agency, a sound system of financial controls, and adherence to our Comprehensive Compliance Strategy and Continuous Monitoring Program. In addition, we continue to be in substantial compliance with the Federal Financial Management Improvement Act. Based on the results of this year's efforts, I am able to provide reasonable assurance that this report's financial data are reliable and complete.

To meet national needs, President Barack Obama has given NASA and our partners a grand challenge to out-innovate, out-educate, and out-build our competitors, and to create new capabilities that will take us farther into the solar system while learning about our place in it. Our accomplishments this year herald our progress toward meeting this grand challenge. The hard work, expertise, and dedication of NASA's employees and partners have enabled us to come this far, and will be critical as we continue to do the big things only NASA can do and challenge ourselves as a people to reach our highest potential. As we close this fiscal year and begin another, we will continue our commitment to being an exceptional resource for exploration, innovation, discovery, and education for this Nation, and we look forward to the challenges and opportunities that the next year will bring us.

Charles F. Bolden, Jr.
Administrator

# Table of Contents

# Management's Discussion and Analysis

Photo, previous page: The bright Sun, a portion of the International Space Station, and Earth's horizon are featured in this image photographed during the STS-134 mission's fourth spacewalk in May 2011. The image was taken using a fish-eye lens attached to an electronic still camera. (Credit: NASA)

Fiscal Year 2011

# Welcome to NASA

NASA was created by the National Aeronautics and Space Act of 1958 to provide for research into problems of flight within and outside the Earth's atmosphere and to ensure that the United States conducts activities in space devoted to peaceful purposes for the benefit of mankind. In 2010, the President unveiled an ambitious new direction for NASA, laying the groundwork for a sustainable program of exploration and innovation. Called the National Space Policy, this direction extends the life of the International Space Station (ISS), supports the growing commercial space industry, and addresses important scientific challenges. It also continues NASA's commitment to robust human space exploration, science, and aeronautics programs. Later in 2010, Congress passed the NASA Authorization Act of 2010, which provided the Agency important guidance on program content and conduct.

On February 14, 2011, NASA released a new Strategic Plan that embraces the spirit, principles, and objectives of this and other recent policies and legislation.[1] The plan introduced a new framework for outlining NASA's strategic direction.

### The NASA Vision

To reach for new heights and reveal the unknown, so that what we do and learn will benefit all humankind.

### The NASA Mission

Drive advances in science, technology, and exploration to enhance knowledge, education, innovation, economic vitality, and stewardship of Earth.

The plan included a Vision statement[2] and a new Mission statement.

The following overarching strategies, as defined in the 2011 Strategic Plan, govern the management and conduct of NASA's aeronautics and space programs. These are standard practices that each organization employs in developing and executing their plans to achieve the Agency's strategic goals and annual performance plan. They also provide a framework that guides the way NASA supports other areas of national and Administration policy: government transparency; science, technology, engineering, and mathematics (STEM) education; energy and climate change; innovation; and increased citizen and partnership participation to help address challenges faced by the Nation.

- **Investing in next-generation technologies** and approaches to spur innovation;
- **Inspiring students** to be the future scientists, engineers, explorers, and educators through interactions with NASA's people, missions, research, and facilities;
- **Expanding partnerships** with international, intergovernmental, academic, industrial, and entrepreneurial communities and recognizing their role as important contributors of skill and creativity to NASA's missions and for the propagation of NASA's results;

1. In 2006, the Administration published the National Aeronautics Research and Development Policy, guiding the Nation's goals in aeronautics technology research and development.
2. Although NASA has had Vision statements in the past, for the 2006 Strategic Plan NASA senior management chose to not include a Vision statement.

- **Committing to environmental stewardship** through Earth observation and science, and the development and use of green technologies and capabilities in NASA missions and facilities; and
- **Securing the public trust** through transparency and accountability in NASA's programmatic and financial management, procurement, and reporting practices.

# NASA's Organization

NASA's science, research, and technology development work is focused and implemented through three mission directorates and assisted by the mission support directorate. Additionally, NASA has three offices that directly support NASA's Mission and Vision.

The **Aeronautics Research Mission Directorate (ARMD)** explores early-stage concepts and ideas, develops new technologies and operational procedures through foundational research, and demonstrates the potential of promising new vehicles, operations, and safety technology in relevant environments. ARMD is focused on cutting-edge research and technologies to overcome a wide range of aeronautics challenges for the Nation's current and future air transportation system.

The **Human Exploration and Operations (HEO) Mission Directorate** was newly formed in August 2011. It merged the Exploration Systems and Space Operations Mission Directorates, creating an organization dedicated to enabling human and robotic space exploration. HEO operates the International Space Station and is developing technologies and capabilities for human exploration beyond low Earth orbit. It manages the commercial crew and cargo developmental programs, construction of the Orion Multi-Purpose Crew Vehicle, development of a new heavy lift rocket known as the Space Launch System, launch operations, space communications, rocket propulsion testing, human health and safety, and exploration technology development, the latter to enable human exploration of deep space.

The **Science Mission Directorate (SMD)** conducts the scientific exploration of Earth, the Sun, the solar system, and the universe. SMD's missions include ground-, air-, and space-based observatories, deep-space automated spacecraft, planetary orbiters, landers, and surface rovers. SMD also develops innovative science instruments and techniques in pursuit of NASA's science goals.

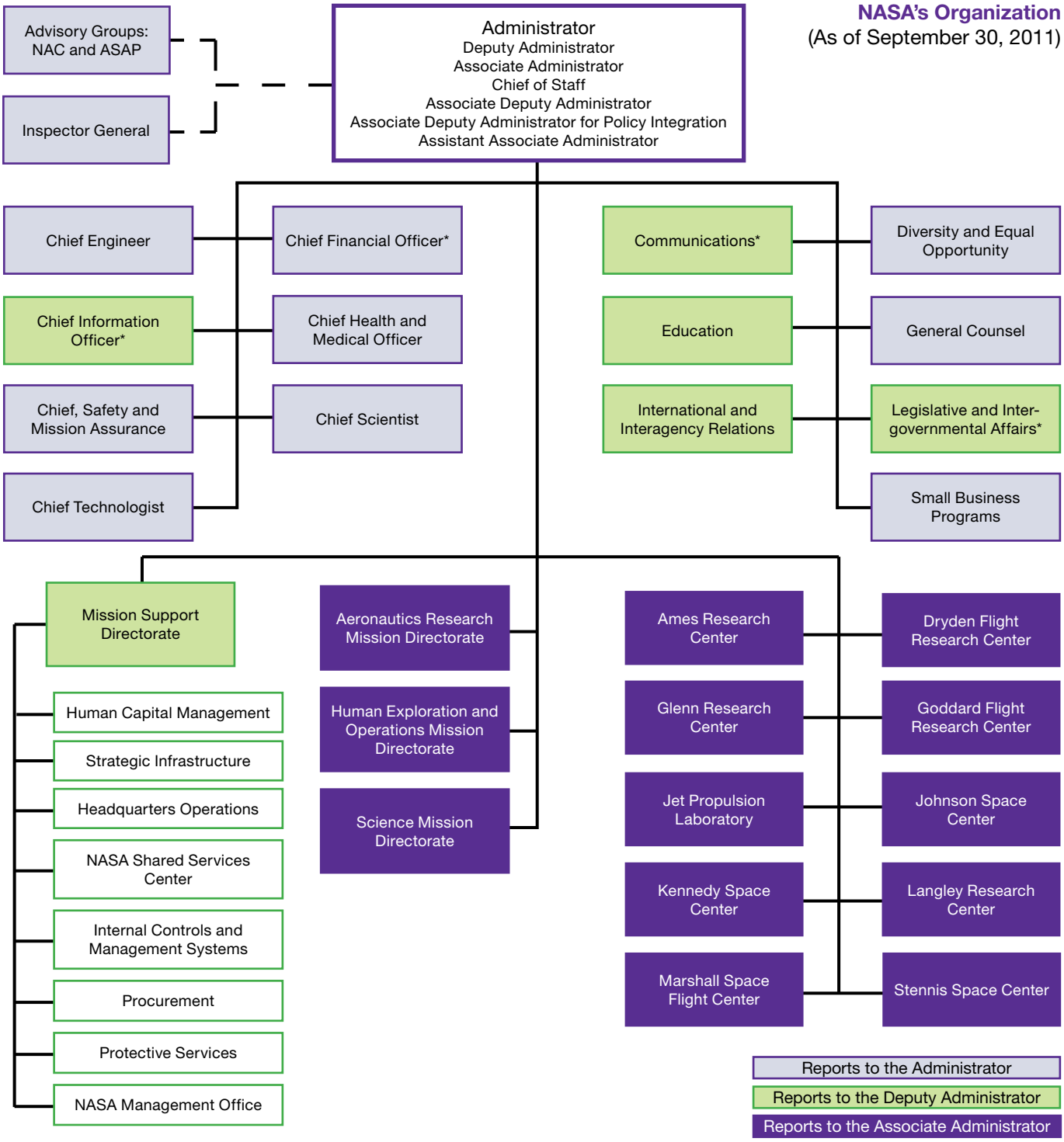
The **Mission Support Directorate (MSD)** strengthens the efficiency and management of Agency-level operations under a single associate administrator. MSD includes Agency and Center management and operations, facility construction, budget and finance, information technology, human capital management, and infrastructure. Organizing NASA's mission support services into a mission directorate ensures that management practices are uniform across the Agency and that these support services maintain maximum visibility inside and outside the Agency.

The **Office of Education (Education)** is responsible for developing and managing a portfolio of programs that translate NASA's mission focus and achievements into educational activities, tools, and opportunities for students and teachers at all levels. Education's goals are to strengthen the future workforce for the benefit of NASA and the Nation, attract and retain students in STEM disciplines, and engage the public in NASA's missions. To achieve these goals, Education partners with other government agencies, non-profit organizations, museums and education centers, and the education community at large.

The **Office of the Chief Technologist (OCT)** is the principal advisor and advocate on matters concerning Agency-wide technology policy and programs. OCT directly manages NASA's Space Technology programs and coordinates and tracks all technology investments across the Agency.

The **Office of the Chief Scientist** is the principal advisor and advocate on Agency science programs, strategic planning, and the evaluation of related investments. The Office of the Chief Scientist represents the scientific endeavors in the Agency, ensuring they are aligned with and fulfill the Administration's science objectives.

## NASA's Organization
(As of September 30, 2011)

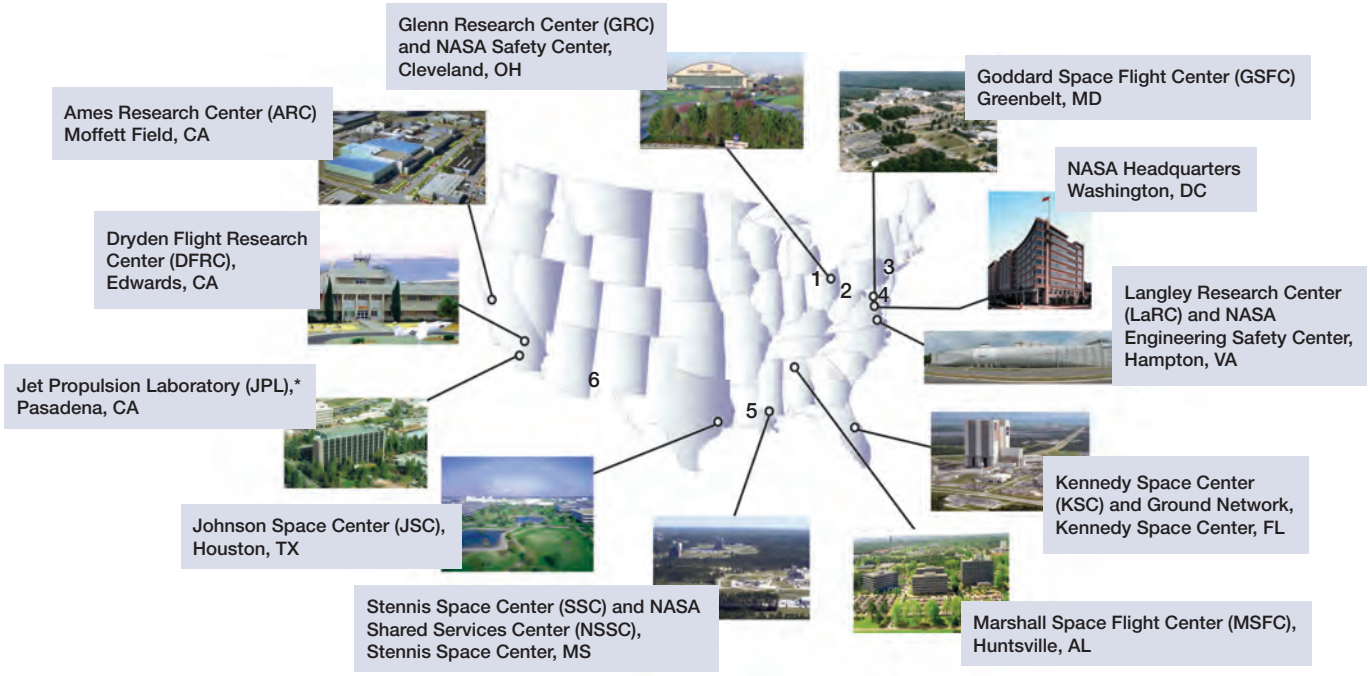



*Center functional office directors report to Agency functional Associate Administrators. Deputy and below report to Center leadership. Dashed lines indicate independent organizations that report to the Administrator.

The Administrator's Staff Offices provide a range of high-level guidance and support in critical areas like safety and mission assurance, technology planning, education, equal opportunity, information technology, financial administration, small business administration, international relations, and legislative and intergovernmental affairs.

NASA is comprised of Headquarters in Washington, DC, nine Centers located around the country, and the Jet Propulsion Laboratory, a federally funded research and development center (FFRDC) operated under a contract with the California Institute of Technology. In addition, NASA partners with academia, the private sector, state and local governments, other Federal agencies, and a number of international organizations to create an extended NASA family.

**NASA Centers and Facilities Nationwide**




*The Jet Propulsion Laboratory is an FFRDC. The workforce are employees of the California Institute of Technology.

Other NASA facilities noted on the map by number include: 1) Plum Brook Station, Sandusky, OH, managed by GRC; 2) Software Independent Verification and Validation Facility, Fairmont, WV, managed by GSFC; 3) Goddard Institute for Space Studies, New York, NY, managed by GSFC; 4) Wallops Flight Facility, Wallops, VA, managed by GSFC; 5) Michoud Assembly Facility, New Orleans, LA, managed by MSFC; and 6) White Sands Test Facility and Space Network, White Sands, NM, managed by JSC.

For more information about NASA's organization go to http://www.nasa.gov/about/org_index.html.

# NASA's Workforce

As of August 18, 2011, NASA employed more than 18,500 on-duty civil servants (full-time, part-time, term appointment, student and other non-permanent) at nine Centers, Headquarters, and the NASA Shared Services Center, with approximately 5,000 people at the Jet Propulsion Laboratory. To see more information about workforce profile and distribution, visit the Workforce Information Cubes for NASA at http://wicn.nssc.nasa.gov/.

This year, the Office of Human Capital Management (OHCM) released a Workforce Plan that outlines the policies, processes, and structures needed to ensure that critical workforce skills and capabilities are available and effectively used in the timeframe needed to enact the major activities of the Agency's Mission. The 2011 Workforce Plan has an overarching strategic workforce goal—identify, acquire, and sustain the workforce needed to successfully conduct NASA's current and future missions—supported by five workforce goals:

- **Workforce Goal 1:** Plan strategic human capital and position for mission success—Analyze, develop policy, conduct organizational design and resource alignment to guide NASA's multi-sector workforce.
- **Workforce Goal 2:** Recruit and employ a highly qualified, diverse workforce—Identify, attract, and employ a diverse workforce with the right skills, at the right time, at the right place.
- **Workforce Goal 3:** Train and develop talent—Create and conduct training and development initiatives that address today's and tomorrow's needs and enable mission success.
- **Workforce Goal 4:** Sustain a high-performing workforce—Enable managers to sustain an environment conducive to workforce productivity, innovation and effectiveness.
- **Workforce Goal 5:** Enable efficient human capital services—Develop effective human resources programs supported by comprehensive, timely, and validated information.

OHCM will revise the Workforce Plan to support NASA's evolving strategic direction and priorities and changing workforce needs.

# Shared Values, Shared Results

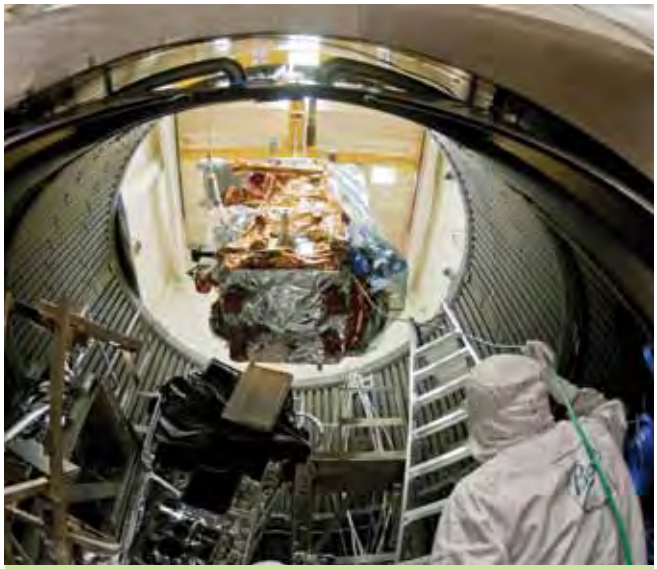
NASA believes that mission success is the natural outcome of an uncompromising commitment to the Agency's four shared core values: safety, integrity, teamwork, and excellence.

**Safety:** Constant attention to safety is the cornerstone of mission success. NASA is committed, individually and as a team, to protecting the safety and health of the public, NASA team members, and the assets that the Nation entrusts to the Agency.

**Integrity:** NASA is committed to maintaining an environment of trust, built on honesty, ethical behavior, respect, and candor. Agency leaders enable this environment by encouraging and rewarding a vigorous, open flow of communication on all issues, in all directions, and among all employees without fear of reprisal. Building trust through ethical conduct as individuals and as an organization is a necessary component of mission success.

**Teamwork:** NASA's most powerful tool for achieving mission success is a multi-disciplinary team of diverse, competent people across all NASA Centers. NASA's approach to teamwork is based on a philosophy that each team member brings unique experience and important expertise to project issues. Recognition of, and openness to, that insight of individual team members improves the likelihood of identifying and resolving challenges to safety and mission success. NASA is committed to creating an environment that fosters teamwork and processes that support equal opportunity, collaboration, continuous learning, and openness to innovation and new ideas.

**Excellence:** To achieve the highest standards in engineering, research, operations, and management in support of mission success, NASA is committed to nurturing an organizational culture in which individuals make full use of their time, talent, and opportunities to pursue excellence in both the ordinary and the extraordinary.



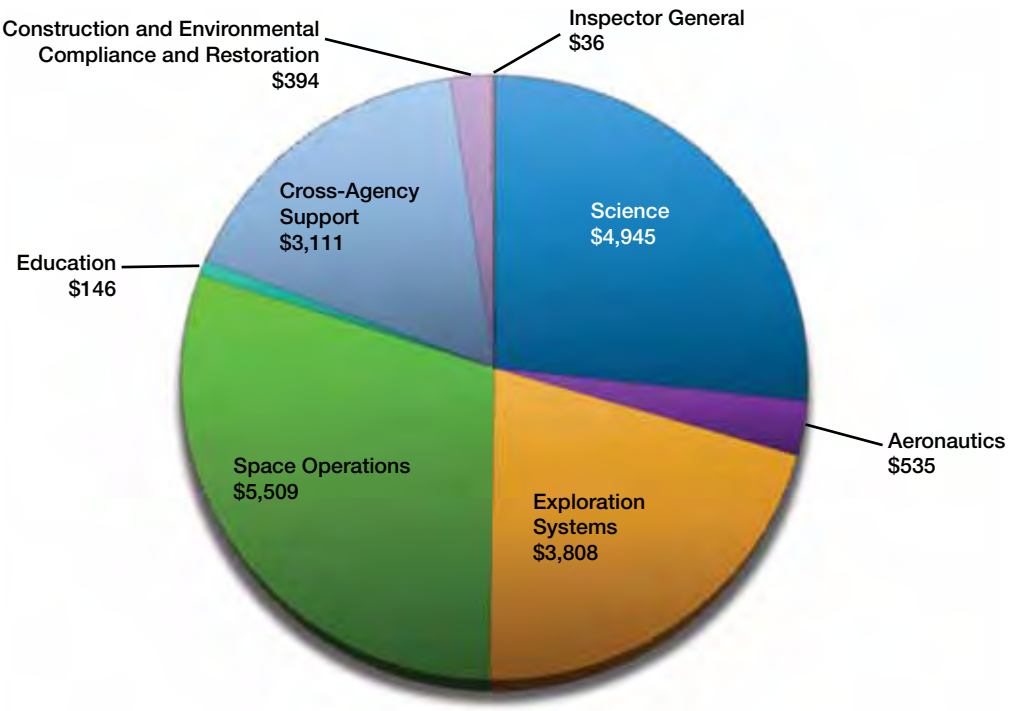
An engineer from Ball Aerospace guides the NPOESS Preparatory Project (NPP) satellite into a thermal vacuum chamber for environmental testing. Once the satellite is inside, the air is pumped out of the chamber and temperature extremes are applied to replicate orbit conditions. Completing a project like NPP requires dedication, teamwork, and attention to detail from all participants—NASA, contractors, and partners. (Credit: Ball Aerospace)

# Budget for Performance: NASA's FY 2011 Budget

On April 15, 2011, President Barack Obama signed into law a full-year continuing resolution (CR) for fiscal year 2011.[1] Congress uses CRs to continue funding government functions if an appropriations bill has not been signed into law by the end of the fiscal year. This authorizes agencies to fund their programs at the existing or a reduced level, until either the resolution expires, or an appropriations bill is passed.

The 2011 CR, which gave NASA $18,485 million for the fiscal year, directed NASA to pursue the human exploration goals set in the NASA Authorization Act of 2010 and called for the development of the Space Launch System and a Multi-Purpose Crew Vehicle. The chart below shows the details of the CR by each of NASA's appropriation accounts.[2]

**Full-Year Continuing Appropriations Act of 2011, Total $18,485**
(Dollars in Millions)




Note: NASA merged Exploration Systems and Space Operations into a new, single organization, Human Exploration and Operations, later in the fiscal year.

NASA's budget requests are available online at http://www.nasa.gov/news/budget/index.html.

1. Department of Defense and Full-Year Continuing Appropriations Act of 2011 (P.L. 112-10).
2. In the FY 2011 Budget Request, NASA requested that an appropriation account be created for Aeronautics and Space Technology, which would fund both aeronautics and space research and technology activities. Under the year-long CR, the activities associated with space research and technology remained in existing accounts, and NASA began new Space Technology initiatives in the Space Operations account. These initiatives are guided by the Office of the Chief Technologist.

# Continuing Performance on the Implementation of the American Recovery and Reinvestment Act

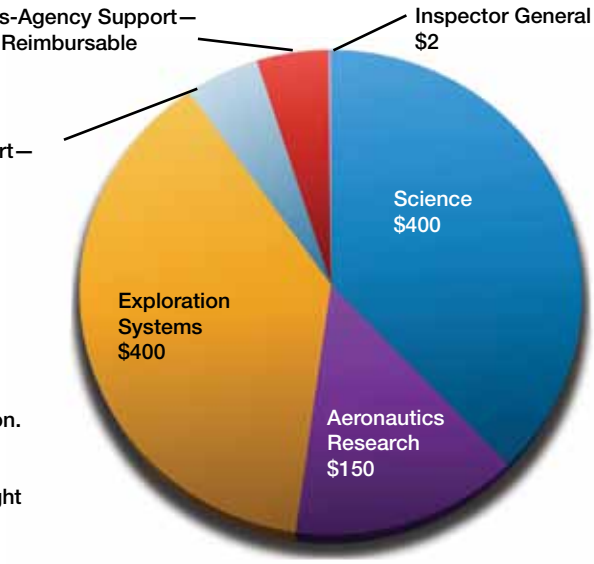
The American Recovery and Reinvestment Act of 2009 (Recovery Act) was signed into law by President Obama, on February 17, 2009. It was an unprecedented effort to jump-start the Nation's economy by creating and saving jobs and investing in long-term growth, while holding the Federal government to levels of accountability and transparency in spending,

NASA received $1,050 million of Recovery Act funding in FY 2009 ($1,002 million Direct Appropriation and $48 million Reimbursable Authority), all of which was obligated to projects to support the Nation's economic recovery and advance NASA's research mission. The Agency received an additional $4 million in Recovery Act Reimbursable Authority in FY 2010. NASA provides an overview of the Recovery Act and NASA's implementation efforts at http://www.nasa.gov/recovery/index.html.

Since the Recovery Act was signed into law, NASA leveraged its funding to achieve the purposes set forth by this important law. NASA's Recovery Act funds augmented research and development activities in the key program areas of Aeronautics Research, Science (with an emphasis on Earth Science and Astrophysics), and Exploration and were used to restore critical NASA-owned facilities damaged from hurricanes during 2008.

**NASA Recovery Act Funding Total: $1,054**
(Dollars in Millions)

- **Restore NASA-owned facilities damaged by hurricanes and other natural disasters that occurred in 2008.**




- **Accelerate the development of Earth science climate research missions recommended by the National Academies' decadal survey.**
- **Increase NASA's supercomputing capabilities.**

- **Fund planned mission development activities that could contribute to future exploration.**
- **Stimulate efforts within the private sector to develop and demonstrate human spaceflight capability.**

- **Undertake systems-level research, development, and demonstration activities related to aviation safety, environmental impact mitigation, and development of the Next Generation Air Transportation System (NextGen).**

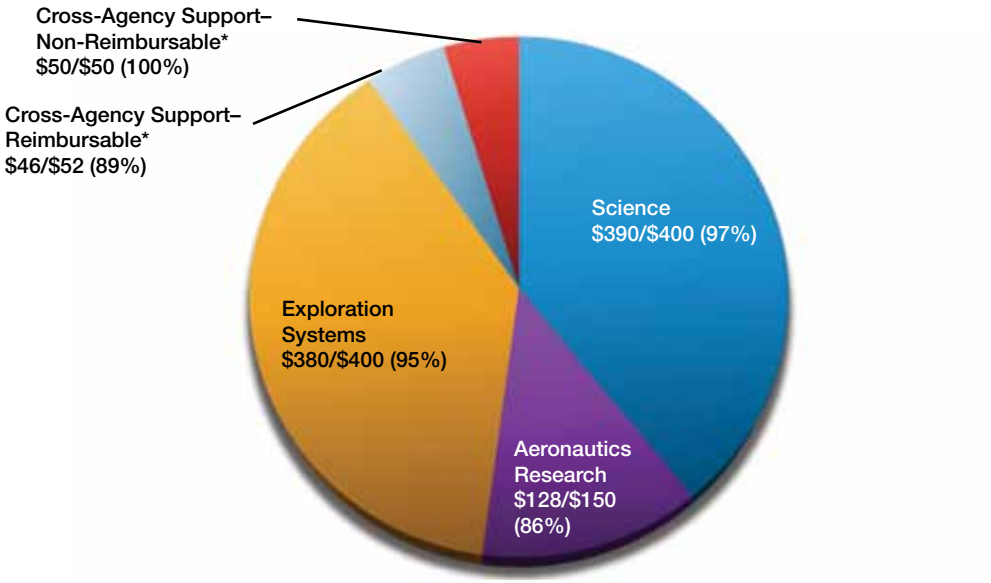
*Reimbursable activities for other Federal agencies' Recovery Act programs.

Highlights of NASA's investments included:

- Undertaking systems-level research, development and demonstration activities related to aviation safety, environmental impact mitigation, and Next Generation Air Transportation System (NextGen) activities;
- Accelerating development of Tier 1 Earth science climate research missions recommended by the National Academies' decadal survey;
- Increasing the Agency's supercomputing capabilities; and
- Stimulating efforts within the private sector to develop and demonstrate technologies that enable commercial human spaceflight capabilities.

In FY 2011, NASA effectively spent the money entrusted to the Agency by Congress by completing the majority of planned work. As of September 30, 2011, NASA has disbursed over $994 million (94 percent) of its Recovery Act funds available through September 30, 2010 (shown in the chart below). Also of note, NASA contractors and grantees have completed an additional $33.5 million of work to bring the total expenditure to 97.5 percent of the Recovery Act funds. NASA expects to complete the remaining Recovery Act activities by September 30, 2013. The Inspector General funds are not included in the chart below as these amounts are available through September 30, 2013.

**NASA Recovery Act Disbursed Total: $994/$1,054, 94%***
(Dollars in Millions)




*Ratio compares disbursed amounts to total available resources.

## Recovery Act funding supports instrumentation for NASA's IceBridge mission

In 2009, the Center for Remote Sensing of Ice Sheets (CReSIS) at the University of Kansas received Recovery Act funds to participate in NASA's IceBridge mission by helping to provide four specialized radars for the aircraft flying the mission. IceBridge, the largest airborne survey of Earth's polar ice ever flown, is monitoring polar regions with instrumented aircraft until the launch of ICESat-II.

CReSIS developed a radar instrumentation package in less than six months and deployed it on NASA's aircraft. IceBridge used the resulting systems during the 2010 and 2011 deployments to Greenland. The CReSIS team perform measurements in conjunction with laser surface elevation measurements being performed by NASA Centers. Scientists around the world are using the data collected by the instrumentation to improve ice-sheet models. This project provided an excellent opportunity to train both graduate and undergraduate students in a multidisciplinary design environment, and provided them an avenue to learn rapid prototyping and development of hardware that must conform to aircraft certification standards. The project involved a local industry in the development process and also has enabled other joint projects that include local industry.

An aerospace engineering student at CReSIS (top) had the opportunity to see the development progress for the fuselage-mounted Multichannel Coherent Radar Depth Sounder (MCoRDS) instrument from a computer aided structural design to the actual installation on the aircraft. The photo below shows MCoRDS being installed at NASA's Wallops Flight Facility. (Credit, top: CReSIS; below: NASA)

# Performance

## Results

NASA has a culture of performance and data-driven performance management, as periodically recognized by Congress, the Government Accountability Office, and the Office of Management and Budget. In recent years, the Agency has worked hard to improve its performance management system to increase accountability, transparency, and oversight. NASA continues to add sophistication and discipline to this system, leading to more consistent performance results across NASA's missions and to make the best use of the resources entrusted to the Agency by Congress and the American people.

In FY 2011, NASA said farewell to the Space Shuttle and continues to look forward to future years of performance in all program areas: aeronautics, science, and human space flight. Shortly after the last flight, Administrator Bolden announced a launch vehicle design for a new deep space exploration system to follow the Space Shuttle. This new heavy-lift rocket will be America's most powerful since the Saturn V rocket, which carried Apollo astronauts to the Moon, and it will launch humans to explore new deep-space destinations like asteroids, Mars, and its moons.

The Agency also unveiled six new strategic goals that emphasize the cooperative, cross cutting nature of NASA's missions and operations. They focus on the valued contributions of NASA's science and exploration missions, as well as aeronautic and space technology research.

NASA made improvements to its performance management system with a new performance framework, based on the strategic goals, that uses a revised rating criteria to conduct quarterly reviews of performance goals (including high priority performance goals) and annual performance goals.

This Performance Results section presents:

- A tribute to NASA's Space Shuttle Program in recognition of its contribution to human exploration and in celebration of its successful retirement;
- NASA's new performance framework;
- An explanation of how NASA measures and manages its performance;
- A summary of NASA's performance against its FY 2011 goals;
- The FY 2011 cost toward its strategic goals;
- Performance highlights for each strategic goal; and
- A summary of verification and validation practices for assuring the integrity of NASA's performance data.

# End of an Era, Dawn of a New Beginning

## The Space Shuttle and Thirty Years of Performance

The Hubble Space Telescope. The International Space Station. The Galileo robotic Jupiter spacecraft. The Chandra X-ray Observatory. Each of these missions has one thing in common: they were made possible by the Space Shuttle. In its 30 years of operation, the Space Shuttle Program accomplished amazing things, advancing technology and affecting the lives of people across the globe.

The Space Shuttle Program was a remarkable chapter in America's history in space. The five orbiters, *Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavour*, flew 135 times, carrying more than 360 people into space and traveling more than 500 million miles. The Space Shuttle Program was a core part of NASA's strategic plan for over three decades, and this amazing vehicle enabled NASA and the Nation to do great things in space.

NASA's Space Shuttle fleet began setting records with its first launch on April 12, 1981, and continued to set high marks of achievement and endurance through 30 years of missions. Starting with *Columbia* and continuing with *Challenger*, *Discovery*, *Atlantis*, and *Endeavour*, the Space Shuttle fleet carried people into orbit, launched, recovered and repaired satellites, conducted cutting-edge research and built the largest structure ever assembled in space, the International Space Station (ISS). The final Space Shuttle mission, STS-135, ended July 21, 2011, when *Atlantis* rolled to a safe stop at its home port, NASA's Kennedy Space Center in Florida.

In its 30 years of performance, crew members spent a total of 198,728.25 hours (approximately 8,280 days) on Space Shuttle, and deployed 179 payloads. They also returned 52 payloads from space back to Earth. Space Shuttle crews retrieved and repaired then re-deployed seven payloads, including the Hubble Space Telescope and the Solar Max satellite. The Shuttle docked with the *Mir* space station nine times, and with the International Space Station 36 times. The Space Shuttle launched over 4.4 million pounds of cargo mass into space and, unique to the Shuttle, returned almost 230,000 pounds of cargo back to Earth. Collectively, the orbiters spent a total of 1,310 days (31,440 hours, 59 minutes, 33 seconds) in space, orbiting Earth 20,830 times.

In 2004, NASA was given two strategic goals for the Space Shuttle: complete assembly of the ISS and fly safely through their retirement. NASA has completed both these goals. As it did during the first three decades of Space Shuttle flight, the performance of the Space Shuttle Program has always reached for the greatest heights to deliver benefits to all humankind.

Designed to return to Earth and land like a hypersonic glider, the Space Shuttle was the first successful reusable space vehicle. The Space Shuttle pushed the boundaries of discovery ever farther, requiring not only advanced technologies but the tremendous effort of a dedicated nationwide workforce. Thousands of civil servants and contractors across the Nation at NASA's Centers have demonstrated an unwavering commitment to mission success and the greater goal of space exploration.

To this day, the Space Shuttle remains the fastest winged vehicle ever to fly, with an orbital velocity of 17,500 miles per hour, 10 times the speed of a high-powered rifle bullet. Additionally, the Space Shuttle carried cargos of substantial weight and dimensions and ultimately returned from orbit more than 97 percent of all mass returned to Earth.

On April 12, 1981, a bird flies away from Launch Complex 39's Pad A as something new takes to the sky—America's reusable Space Transportation System (STS). Designated STS-1, Space Shuttle *Columbia* launches on its historic maiden voyage carrying astronauts John Young and Bob Crippen. (Credit: NASA)

In addition to the advances required for the spacecraft's development, science has made huge strides with the help of the Space Shuttle. NASA researchers have learned more about how human bodies and those of other organisms function, from the subcellular level on up. They have learned how people as individuals interact with one another under unusual and stressful circumstances—and how to work together. The Space Shuttle has revealed more about Earth, its land masses, oceans, atmosphere, and environment as a whole. It also has been instrumental in learning more about the Moon, the solar system, the Milky Way galaxy, and the universe. For example, Space Shuttle missions launched and repeatedly upgraded and repaired the Hubble Space Telescope, which has provided unprecedented vision of distant stars, some with planets orbiting them. It has allowed humankind to look at objects so distant that viewing the light from them is looking back in time to witness the beginning of the universe.

Astronaut Story Musgrave, anchored on Space Shuttle *Endeavour*'s robotic arm, prepares to be elevated to the top of the Hubble Space Telescope during Hubble's first servicing mission, in 1993. Astronaut Jeffrey Hoffman, inside the Shuttle payload bay, assists Musgrave. The mission replaced and repaired various instruments, but its most important task was installing technology that corrected the tiny flaw in Hubble's main mirror that distorted the telescope's view. (Credit: NASA)

Scientific advances continue aboard the ISS. Without the Space Shuttle, this orbiting research facility simply could not have been built. Perhaps as important as any element of the Space Shuttle legacy is the development of international cooperation in space. Humans from many nations have begun to work together in space. Space Shuttle visits to the Russian space station *Mir* were a beginning that led to the new cooperation we see today aboard the ISS. It has helped to develop understanding for people from many countries, including some former enemies. Such synergies will give humans as a whole greater potential for space exploration and development that any single nation could achieve alone. The Space Shuttle has provided inspiration—for the young and the not so young. It has encouraged uncounted young students to focus on science and technology. The idea of becoming an astronaut, as some certainly will, is a powerful motivation. So too is the prospect of using such an education to advance human knowledge and understanding in space. People of all the nations contributing to the Space Shuttle's design and operation can take pride in its accomplishments.

Now, the Space Shuttle ushers in the next extraordinary installment in the Nation's story of exploration. The Space Shuttle concluded its historic mission by completing construction of the ISS, the anchor of NASA's human space flight activities for the next decade. Six-member crews will be living and working aboard the ISS around the clock until at least 2020. The ISS will be the centerpiece of our human spaceflight activities for the coming years, and the research and technology breakthroughs aboard the ISS will facilitate our travel to destinations beyond low Earth orbit.

Workers measured and marked in bright red the letters "MLG" at the spot where Space Shuttle *Atlantis*' main landing gear came to rest after the vehicle's final return from space. Securing the Space Shuttle fleet's place in history on the STS-135 mission, *Atlantis* safely and successfully rounded out NASA's Space Shuttle Program on the Shuttle Landing Facility's Runway 15 at Kennedy Space Center in Florida. Main gear touchdown was at 5:57:00 a.m. EDT on July 21, 2011, followed by nose gear touchdown at 5:57:20 a.m., and wheel stop at 5:57:54 a.m. (Credit: NASA/K. Herring)

The Space Shuttle Program will continue to shape humankind's vision of exploration. The orbiters will live on in museums around the country, inspiring millions of visitors to look up and dream. Though the orbiters themselves will no longer fly, technology from the Space Shuttle will be used in the design of the Space Launch System, NASA's new deep space launch vehicle. The aspiring astronauts of today may not fly the Space Shuttle, but they may soon have the opportunity to walk on Mars.

**On to 30 more years of NASA's performance in human space flight, science, aeronautics, and space technology development. . . .**

Above: Vapor trails follow Space Shuttle *Atlantis* as it approaches Runway 15 at the Kennedy Space Center for the final time. *Atlantis* marked the 26th nighttime landing of the Space Shuttle and the 78th landing at Kennedy. It also was the final mission for the Space Shuttle Program. (Credit: NASA/S. Joseph and K. O'Connell)

# A New Strategic Plan and Performance Framework

On February 14, 2011, NASA released a new Strategic Plan outlining six new strategic goals. For the first time the Agency has a strategic goal that emphasizes the importance of supporting the underlying capabilities that enable NASA's missions. This addition ensures that resource decisions directly address the balance of funding priorities between missions and the requirements of institutional and program capabilities that enable the missions.

At the heart of NASA's strategic goals remain the core missions of human space exploration, Earth and space science, aeronautics, and technology development. The 2011 Strategic Plan elevates the science and aeronautics missions from sub-goals to strategic goals and once again establishes education and outreach as fundamental Agency activities. NASA's new strategic goals are as follows:

- **Strategic Goal 1:** Extend and sustain human activities across the solar system.
- **Strategic Goal 2:** Expand scientific understanding of the Earth and the universe in which we live.
- **Strategic Goal 3:** Create the innovative new space technologies for our exploration, science, and economic future.
- **Strategic Goal 4:** Advance aeronautics research for societal benefit.
- **Strategic Goal 5:** Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.
- **Strategic Goal 6:** Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation, and contribute to a strong national economy.

## Changes to NASA's Performance Framework

NASA revised the performance framework supporting these strategic goals, as well, to increase transparency by providing more insight into the Agency's performance against its mid- and near-term plans. This new framework guided development of the FY 2011 Performance Plan being reported on in this document.

The former strategy-performance framework, was based on the 2006 Strategic Plan, and consisted of three levels: strategic goals (and sub-goals), outcomes, and annual performance goals (APGs). The new strategy-performance framework consists of four levels of performance measures, mapped to the strategic goals. The four distinct levels supporting the achievement of the overarching goals are outcomes, objectives, performance goals, and annual performance goals.

Each performance level is associated with a specific timeframe. In the past, the outcome level was associated by any timeframe beyond the annual. In the new framework outcomes reflect NASA's long-term plans for the next 10 to 20 years and beyond. Objectives identify targets that span the next 10 years. Performance goals focus on planned progress over the next two to five years, and include the high-priority performance goals. Lastly, annual performance goals (APGs) align to the annual budget request.

The figure below compares the former performance framework to the new one.

## Changes to NASA's Rating Criteria and Rated Performance Measures

In FY 2011, NASA chose to pilot refined rating criteria and to rate only the performance goal (two- to five-year target) and APG (annual target) levels as a measurement improvement strategy. In the past, NASA rated the performance against the APGs and outcomes, the latter of which had an open-ended timeframe and, therefore, targets that potentially would never be accomplished fully. Outcomes continue to perform their intended function as long-term, larger scope steps toward achieving the strategic plans.

NASA measures and communicates its progress toward achieving performance goals and APGs through the ratings below. NASA determines these ratings based on a series of internal assessments that are part of ongoing monitoring of NASA's program and project performance. These ratings are then validated externally with entities such as scientific peer review committees, aeronautics technical evaluation bodies, and the Office of Management and Budget prior to provision in the Performance and Accountability Report.

### FY 2011 Pilot Rating Criteria for Performance Goals

| Rating | Performance Goal and High Priority Performance Goal |
|---|---|
| **Green** (On Track) | NASA achieved or expects to achieve the intent of the performance goal or high priority performance goal (HPPG) within the estimated timeframe. NASA achieved the majority of key activities supporting this performance goal or HPPG. |
| **Yellow** (At Risk) | NASA expects to achieve the intent of the performance goal or HPPG within the timeframe; however, there is at least one likely programmatic, cost, or schedule risk to achieving the performance goal or HPPG. |
| **Red** (Not on Track) | NASA does not expect to achieve this performance goal or HPPG within the estimated timeframe. |
| **White** (Canceled or Postponed) | NASA senior management canceled this performance goal and the Agency is no longer pursuing activities relevant to this performance goal or the program did not have activities relevant to the performance goal during the fiscal year. |

### FY 2011 Pilot Rating Criteria for APGs

| Timeframe: When Will the APG Be Achieved | Rating Criteria for APG Types | | | Rating |
|---|---|---|---|---|
| | Single Milestone or Deliverable | Multiple Deliverables, Targeted Performance, and Efficiencies | On-going Activities, Services, or Management Processes | |
| Current FY as planned. | NASA achieved the event or the deliverable met the intent of the APG within the timeframe. | The program/project reached the stated numeric target. | The intended result of the program/project was achieved as defined by internally held success criteria. | **Green** |
| Achieve next FY (will not achieve this FY as planned). | NASA did not achieve this APG in the current fiscal year, but anticipates achieving it during the next fiscal year. | | | **Yellow** |
| Will not be achieved, but progress was made. | N/A | NASA failed to achieve this APG, but made significant progress as defined by reaching 80% of the target or other internally held success criteria. | The intended results of the program/project were not achieved in this fiscal year, but significant progress was accomplished, as defined by internally held success criteria. | |
| Will not be achieved. | NASA did not achieve the APG and does not anticipate completing it within the next fiscal year. | NASA achieved less than 80% of the target or other internally held success criteria. | Neither intended results nor significant progress were achieved. The progress toward the APG does not meet standards for significant progress for the internally held success criteria. | **Red** |
| Will not be achieved due to cancellation or postponement. | NASA senior management canceled this APG and the Agency is no longer pursuing activities relevant to this APG or the program did not have activities relevant to the APG during the fiscal year. | | | **White** |

# Managing and Measuring NASA's Performance

NASA's planning and performance management system is an essential part of strategic management and governance. The Agency has an integrated system to: plan strategy and implementation; monitor, assess, and evaluate performance toward commitments; identify issues; gauge the organization's health; and provide appropriate data and information to NASA decision-makers. NASA's performance data provides a foundation for both programmatic and institutional decision-making processes and supports decisions concerning strategy and budget.

NASA's performance system is designed to align with the Agency's internally and externally imposed performance measurement and reporting requirements, tools, and practices, including the Government Performance and Results Act Modernization Act (GPRAMA) of 2010 and Executive Orders 13450—Improving Government Program Performance and 13576—Delivering an Efficient, Effective, and Accountable Government.

NASA's planning and performance management system provides data to Agency management through the following: ongoing monthly and quarterly analyses and reviews; annual assessments in support of budget formulation (for budget guidance and issue identification, analysis and disposition); annual reporting of performance, management issues, and financial position; periodic, in-depth program or special purpose assessments; and recurring or special assessment reports to internal and external organizations.

## Reviewing Performance at the Senior Management Level

For over four years, NASA has held the Baseline Performance Review, an Agency-level forum for discussing performance and issues chaired by the associate administrator, who also serves as the chief operating officer. Senior management at the mission directorate, program, project and Center-level present institutional, program and project performance. Actions are assigned accordingly to address any issues. Beginning in 2011, NASA initiated quarterly performance self-assessments for the execution year performance plan commitments (i.e., performance goals and APGs, and progress toward achieving high priority performance goals (HPPGs)). For HPPGs, the goal leaders present their progress overall, including progress towards milestones, risks, and coordination efforts. They also request senior management input if required to keep on track.

## Measuring High Priority Performance Goals

Starting in FY 2010, NASA developed and began reporting on a quarterly basis for five HPPGs. In accordance with the GPRA Modernization Act of 2010 and a White House initiative for building a high-performing government, NASA's HPPGs represent challenging, near-term targets that the Agency will reach to benefit the American people in the areas of human exploration, earth science, aeronautics research, and energy management. These five performance goals were chosen by Administrator Bolden for their importance to both NASA's Mission and national priorities (see NASA's FY 2011 Progress Toward the High Priority Performance Goals for more information).

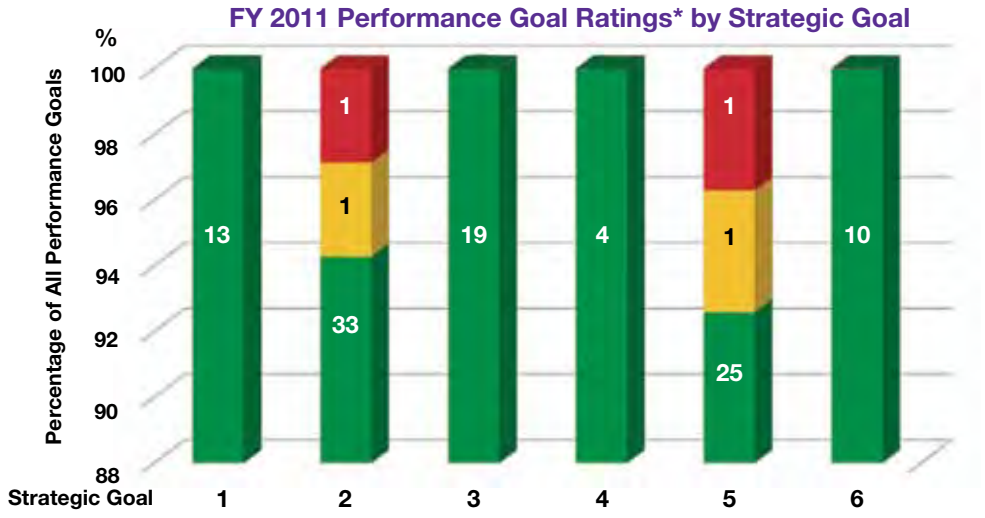
## Setting Performance Improvement Plans

Performance shortfalls identified in FY 2011 can impact the success of activities in subsequent years. Hence, the final performance results reflected in this report will inform planning for the forthcoming FY 2012 Performance Plan and the FY 2013 Congressional Justification. NASA, along with the Government Accountability Office (GAO) and the Office of Inspector General (OIG) monitor the Agency's activities and results to identify weaknesses in or risk to performance. NASA assessed this year's performance shortfalls to project future impacts and to look for any trends across those shortfalls. Additionally, FY 2011 performance challenges were trended with those seen in FY 2010, to provide a more complete picture of what may be the causes for why NASA did not meet its performance targets. NASA couples the results from this and other internal performance assessments with the insights of OIG and GAO to inform actionable plans that strengthen the Agency. See the Performance Improvement Plan Introduction section of Detailed Performance (see page 155) for more details on the performance improvement plans resulting from this performance assessment.

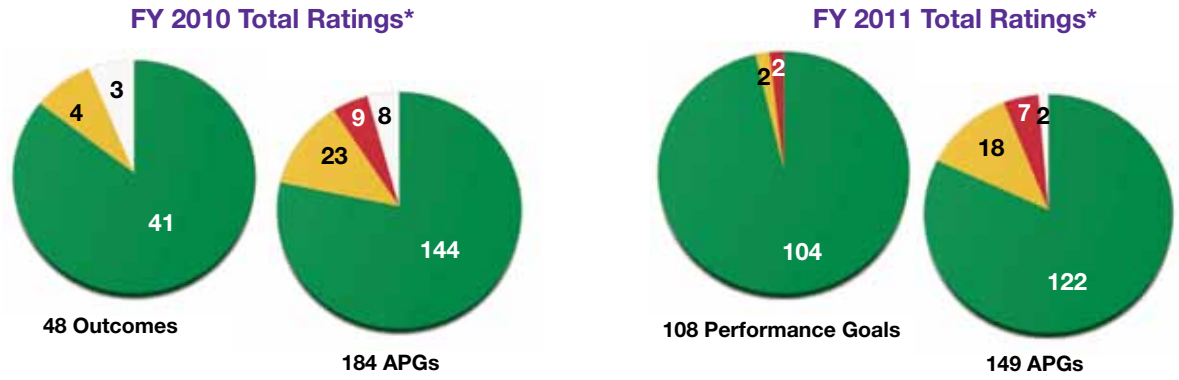
# Summary of Performance Results

In FY 2011, NASA rated 108 two- to five-year performance goals, including the five HPPGs, and 149 APGs under the new rating criteria. Prior to rating these measures, the FY 2011 Performance Plan was updated to reflect changes due to both Congressional budget action and to correct inaccuracies found in several measures, which were not found prior to the measures' provision in the FY 2012 budget submission to the Congress (available at http://www.nasa.gov/news/budget/index.html). For more details on the changes to NASA's FY 2011 Performance Plan, see Changes to the FY 2011 Performance Plan in the Detailed Performance section (see page 43).

The summary of NASA's rated measures by strategic goal is provided below.







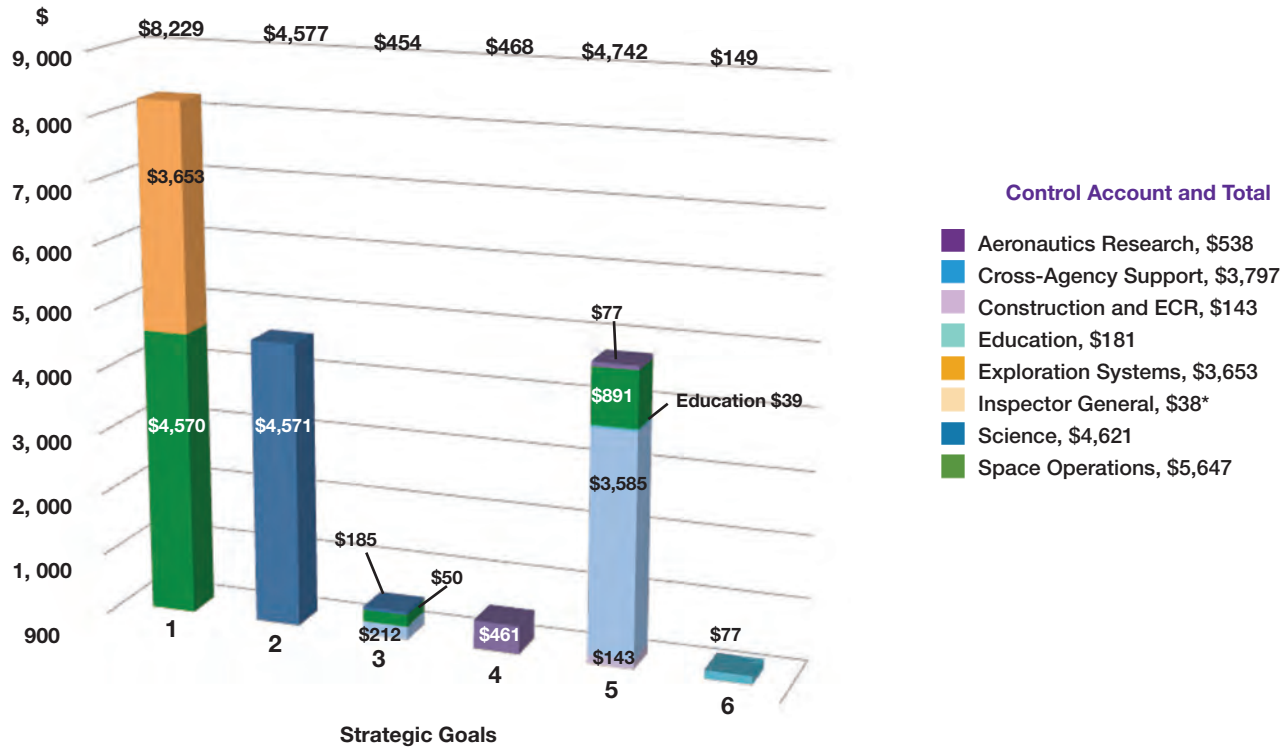

*Numbers denote number of performance measures rated each color.

# FY 2011 Cost Toward Strategic Goals

To measure costs incurred toward strategic goals, NASA maps the net costs (per the Statement of Net Cost) to the strategic goals. First, NASA's maps mission directorate, mission support, and Education control accounts, and their supporting programs to the strategic goal to which they contribute. This performance-to-budget alignment is indicated in the Agency's annual performance plan that links each annual performance goal, and responsible program, to the strategic goals. The net costs for each mission directorate or mission support directorate-level control account are then allocated to a strategic goal by the budget-weighted percentage of its programs' contribution to that goal. NASA bases the budget-weighted percentage on the relationship between the programs and control accounts in the fiscal year's final operating plan (this year issued in August) to determine the programs' proportion of budget within the control account.

FY 2011 is the first year where mission support and education activities map directly to a strategic goal. In previous years, the net costs of mission support and education activities were allocated across all strategic goals. The net costs for the Office of Inspector General remain allocated across all strategic goals by an equal amount.

**Cost Toward Strategic Goals, Total $18,618**
(Dollars in Millions)




*$6 million for Inspector General is allocated to each strategic goal.

# Performance Highlights

## Strategic Goal 1: Extend and sustain human activities across the solar system.

Humanity's interest in the heavens has been universal and enduring. NASA has had the privilege of extending the Nation's reach beyond the confines of Earth for more than 50 years through robotic and human space exploration.

This fiscal year, NASA took steps to combine the Exploration Systems Mission Directorate and the Space Operations Mission Directorate to form a single organization, the Human Exploration and Operations (HEO) Mission Directorate, which focuses on all aspects of space flight. The new organization will manage a portfolio which includes developing space exploration vehicles and support technologies, obtaining expendable launch vehicles from commercial vendors, managing operation and servicing of the International Space Station (ISS), managing ground operations, and other vital services.

### *Making the ISS a world-class research facility*

FY 2011 was a big year for the ISS. The last flights of the Space Shuttle also marked the final delivery of the large sections that form the living spaces, research laboratories, docking modules, robotic arms, and trusses holding the solar panels.

*Discovery* (STS-133) delivered the Italian-built Permanent Multipurpose Module (PMM), named Leonardo, that NASA used to ferry supplies, equipment, experiments and other cargo to and from the International Space Station via the Space Shuttle's payload bay. Now it provides more space and accommodations for research. The ISS also received two more Express Logistics Carriers, unpressurized platforms attached to the exterior of the ISS that can be used for research and storage of large replacement parts and systems.

Robonaut 2 is pictured in the ISS Destiny laboratory on August 22 shortly after it was powered up and teams on the ground sent power to the robot for the first time in space. The red flags tied around its wrists are to remind the crew not to use its arms as handles. About a week later, NASA astronaut Mike Fossum, Expedition 28 flight engineer, works with Robonaut 2. (Credit, both images: NASA)

Having completed assembly, ISS mission priorities have shifted from facility assembly to utilization and research. NASA took the first steps in transitioning management of the ISS National Laboratory to an independent non-profit organization by requesting proposals for management of the National Laboratory in February 2011. In August, NASA selected the Center for the Advancement of Science in Space (CASIS), and began transitioning responsibilities. CASIS will help ensure the ISS' unique capabilities are available to the broadest possible cross-section of the U.S. scientific, technological, and industrial communities and will manage research conducted through the National Laboratory.

While the National Laboratory is in transition, the ISS is already being used to develop technologies that will support future objectives in human space exploration. NASA demonstrated advanced robotics technologies and capabilities in February 2011 when ISS crewmembers used the Special Purpose Dexterous Manipulator (SPDM), also known as the Canadarm2 robotic arm, to extract two large external payloads from Japan's H-11 Transfer Vehicle (HTV). In August, ground controllers used the SPDM to change out a piece of failed external hardware without crew participation. Usually, these types of hardware change-outs are performed by a crew member during an spacewalk, requiring up to 26 crew hours to prepare and perform, outside of the safe confines of the ISS. NASA also is using ISS as a platform to demonstrate key robotics technologies needed to meet future human space exploration objectives. Robonaut 2, the first humanoid robot in space, launched in February 2011 aboard STS-133. Co-developed with General Motors (GM), Robonaut's primary job on the ISS is to demonstrate how a dexterous robot can manipulate mechanisms in a microgravity environment, operate safely in the space environment for extended periods of time, assist with ISS tasks, and eventually interact with astronauts. GM plans to use the results in future advanced vehicle safety systems and manufacturing plant applications.

*Atlantis* (STS-135) delivered the Robotics Refueling Mission (RRM) payload in July and crew members attached it to the outside of ISS. A joint effort between NASA and the Canadian Space Agency (CSA), RRM is designed to demonstrate and test the tools, technologies, and techniques needed to robotically refuel satellites in space—even satellites that were not designed to be serviced in orbit. Payload operations for RRM are planned to begin in FY 2012. Another significant enhancement to the ISS research program in FY 2011 included the delivery of the Alpha Magnetic Spectrometer (AMS), which was delivered in May on *Endeavour* (STS-134). The AMS is a state-of-the-art particle physics detector developed by an international team of 56 institutions from 16 countries. At 15,000 pounds, AMS is the largest scientific payload on the ISS. The AMS experiment will use a large permanent magnet to search for antimatter, dark matter, and dark energy to advance knowledge of the universe and lead to a better understanding of the universe's origin. More information on the many ISS experiments conducted during each Expedition can be found at http://www.nasa.gov/mission_pages/station/main/index.html.

### *NASA announces new homes for Shuttles*

On July 21, 2011, STS-135 touched down at Kennedy Space Center in Florida, ending the last Space Shuttle flight. But it did not mark the end of the Space Shuttle fleet's place in history. On April 12, NASA Administrator Charles Bolden announced the facilities where the four Space Shuttle orbiters will be on permanent display.

*Enterprise*, the first orbiter built, will move from the Smithsonian's National Air and Space Museum Steven F. Udvar-Hazy Center in Virginia to the Intrepid Sea, Air and Space Museum in New York. While *Enterprise* never flew into space; NASA used it for approach and landing tests in 1977. The Udvar-Hazy Center will become the new home for *Discovery*, which retired after completing its 39th mission in March 2011. *Endeavour*, which ended its last flight on June 1, will go to the California Science Center in Los Angeles. Finally, the Shuttle that flew STS-135, *Atlantis*, will take its place of pride at the Kennedy Space Center Visitor Complex in Florida. (Read about other awarded artifacts.)

At the Kennedy Space Center, Space Shuttle Program crews are prepping the orbiters for transfer to their new homes. Prior to their relocation, technicians and engineers are delving deep into the spaceframe, areas that have not been seen in a while because it would have been too invasive. The teams are pulling out components, conducting inspections, and creating a detailed encyclopedia to pass on to future spacecraft designers. Then the crews will put the components back in place. They will remove the Shuttles' engines and replace them with dummy engine nozzles, keeping the real hardware for further study. They also will remove parts that contain harmful elements. After completing these changes, NASA will deliver the Shuttles looking just as they did the last time they flew.

### *Next step in space exploration*

This fiscal year, NASA announced the design of the key elements that will provide initial capability for crewed exploration beyond Earth.

In May 2011, NASA announced that the Multi-Purpose Crew Vehicle (MPCV) will be based on designs originally planned for the Orion Crew Exploration Vehicle. The spacecraft will have a pressurized volume of 690 cubic feet, with 316 cubic feet of habitable space and eventually will provide the habitable volume for missions beyond low Earth orbit.

As the fiscal year drew to a close, NASA looked toward the future with the announcement of its design for a heavy-lift rocket. Called the Space Launch System (SLS), the rocket will be America's most powerful launch vehicle since the Saturn V that carried Apollo astronauts to the Moon. This heavy-lift rocket will be capable of launching humans to new destinations beyond Earth orbit, including to asteroids and Mars.

The decision to build the SLS is the culmination of a months-long, comprehensive review of potential designs to ensure that the Nation gets the best possible rocket for the investment—one that is powerful and evolvable, so that NASA can adapt it to different missions as opportunities arise and new technologies are developed.

MPCV sits in Lockheed Martin's Vertical Testing Facility where it is being assembled and tested. (Credit: Lockheed Martin)

## Strategic Goal 2: Expand scientific understanding of the Earth and the universe in which we live.

NASA's work toward achieving Strategic Goal 2 covers the solar system, from the Sun to the outermost edge of the heliosphere, where the Sun's influence ends, and beyond to the distant reaches of the universe. It includes applications that are part of daily lives, like weather reports and natural hazards monitoring, and science that answers big, fundamental questions: How did life on Earth begin? Is there life elsewhere? How and why are Earth's climate and environment changing? How did stars, planets, and galaxies form and evolve?

The Science Mission Directorate conducts this work through four science themes: Earth Science, Heliophysics, Planetary Science, and Astrophysics. Below are FY 2011 highlights from these themes.

### *Research shows how massive glaciers move*

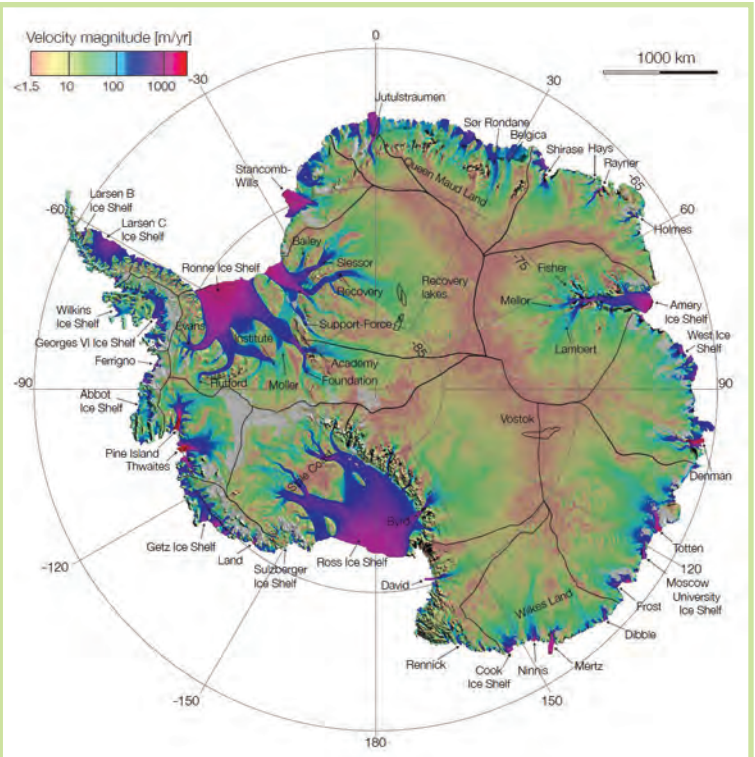
Scientists have not had a clear picture of Antarctic ice-sheet motion at the continental scale—until now. NASA-funded scientists have assembled a comprehensive, high-resolution, digital mosaic of ice motion in Antarctica that confirms some well-know behavior, but also reveals a wealth of new information.

The vast extent of East Antarctica, representing about 77 percent of the continent, has been devoid of quality data. Only a few floating ice shelves have been mapped, and comprehensive velocity mapping has been limited to the lower reaches of key outlet glaciers. This lack of broad-scale detailed observations of ice motion has limited scientists' ability to create numerical models of ice-sheet evolution. These types of models help scientists predict ice loss, sea level changes, climate and weather changes, and other related effects.

This recent, comprehensive survey of Antarctica was obtained using 900 satellite tracks and more than 3,000 orbits of radar data collected during the International Polar Year, dedicated to scientific research of the Arctic and Antarctica. The data came from a variety of orbiting interferometric synthetic aperture radar (InSAR) instruments, including RADARSAT-2 (Canada), Envisat Advanced Synthetic Aperture Radar, or ASAR (Europe), Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Aperture Radar, or PALSAR (Japan) and the European Remote Sensing (ERS) 1/2 satellite (Europe). Each instrument contributed unique coverage and performance.

The data showed that ice velocity ranges from about an inch a year near ice divides to a couple of miles a year on fast-moving glaciers and floating ice shelves. The distribution of velocities has one peak at 13 to 16 feet a year for the slow-moving ice in East Antarctica and another peak at 812 feet (250 meters) a year for fast-flowing glaciers and ice shelves. The scientists found the highest velocities at the Pine Island and Thwaites glaciers of West Antarctica, with rates several times those of any other glacier. This sector of the ice sheet is undergoing the most rapid change at present, over the widest area, and with the greatest impact on the total ice-sheet mass balance.

The mosaic also provides insight into preferred channels of ice transport. It reveals that every major glacier is the merger of several tributaries that extend hundreds of miles inland. The scientists note that in the Antarctic peninsula, the velocities of the tributaries of Wilkins Ice Shelf and




The color-coded map, done on a logarithmic scale and overlaid on a MODIS mosaic of Antarctica, shows the areas of highest ice sheet movement velocities in red and blue, with red exceeding 3,250 feet (1,000 meters) a year. The lowest velocities are in orange and yellow. The black lines delineate ice divides and subglacial lakes. The fast-moving Pine Island and Thwaites glaciers are at center left. The Wilkins and Georges VI ice shelves are on the peninsula at upper left. (Credit: NASA/JPL-Caltech/UCI)

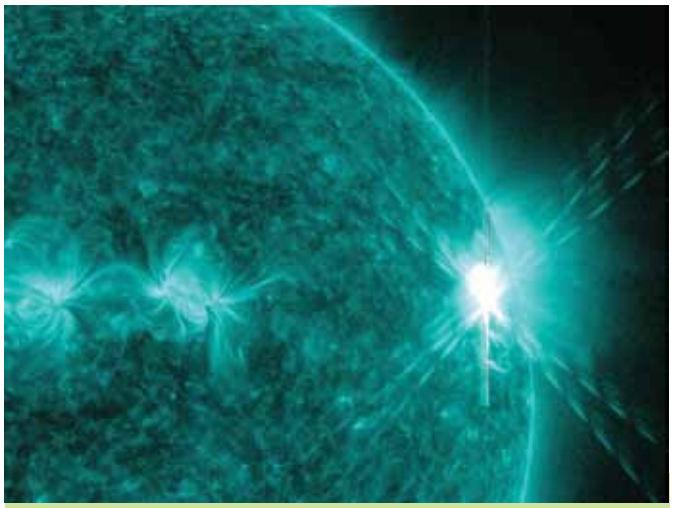
of the northern sector of George VI Ice Shelf abruptly transition to zero when they mix with the floating ice shelves, where ice-shelf melt is greatly increased by the underlying warm ocean.

The observation that ice flow in Antarctica is driven by a complex set of meandering, size-varying, speed-varying, intertwined tributaries—most likely dominated by basal-slip motion, when the weight of a glacier exerts enough pressure to melt the ice where it touches the ground, forming a lubricant—challenges the traditional view of ice-sheet flow constrained by internal deformation, and disconnected from coastal regions. Since this latter view has usually been adopted as the basis for continental-scale ice-sheet modeling, the new reference map will help to improve reconstructions of past and ongoing changes in Antarctica, as well as predictions of future ice-sheet evolution in a warming climate. A paper, Ice Flow of the Antarctic Ice Sheet, about the reference map and related findings was published by *Science* online August 18, 2011.

### *Spacecraft watches the Sun wake from a long solar minimum*

As 2011 unfolded, NASA's Solar Dynamics Observatory (SDO) monitored as the Sun has "woken" from the deepest solar minimum in nearly a century. On February 15 and again on March 9, SDO detected a pair of "X-class" solar flares—a powerful kind of x-ray flare. The last such eruption before February 2011 occurred in December 2006. Another eruption on March 7 hurled a billion ton cloud of plasma away from the Sun at five million miles per hour. The rapidly expanding cloud was strong enough to deliver enough energy into Earth's auroral zone to send the Northern Lights into the lower latitudes of Wisconsin, Minnesota, and Michigan.

Beginning in 2008, sunspots all but vanished, solar flares subsided, and the Sun was eerily quiet. These solar minima come along every 11 years or so as a natural part of the solar cycle, but this particular solar minimum lasted much longer than usual. SDO provides continual full-disk coverage of the Sun at higher resolution, so researchers are able to closely follow changes in solar activity as part of their effort to better understand the Sun's effect on the space environment. With the return of sunspots will come more solar activity including X-class flares and the return of solar maximum, likely in 2013. (Find out more about X-class solar flares.)



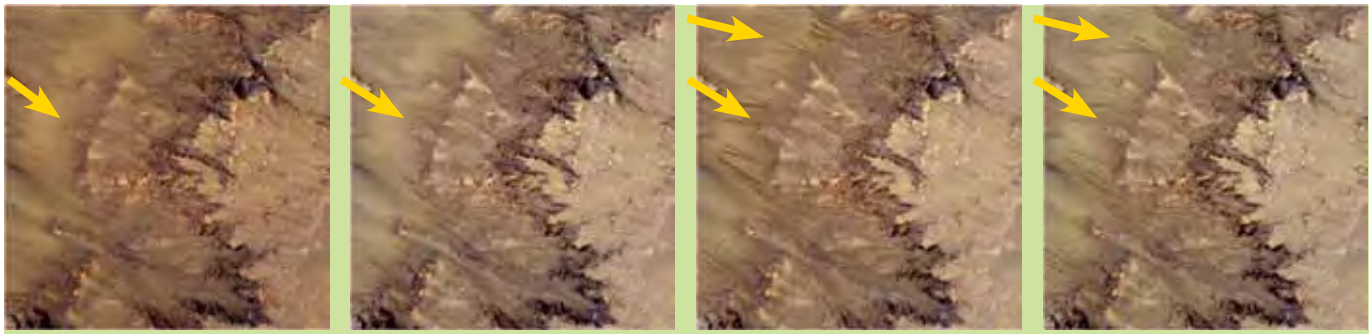
On August 9, 2011, the Sun emitted an X6.9 (an X-class) flare, as observed here by SDO in extreme ultraviolet light. These gigantic bursts of radiation are often associated with solar eruptions known as coronal mass ejections that can cause geomagnetic storms. Effects of these storms can cause disturbances in the uppermost atmospheric layers, which disrupt GPS and communications signals. (Credit: NASA)

Researchers have identified the consequences of the quiet Sun in every part of the heliophysics regime. These include the highest fluxes of cosmic rays recorded by near-Earth spacecraft and extremely low densities of the upper atmosphere that extends the life of potentially harmful space debris in low-Earth orbit. NASA sponsored a research workshop on the Causes and Consequences of Solar Cycle 24. Many processes driven by solar disturbances were considerably quieted during this solar minimum, providing a rare opportunity to study the heliophysics system in an almost "background" state. Many different systems were affected, but one characteristic that all seem to share is that there is more significant coupling between regions than previously thought.

### *New evidence suggests water flowing on Mars*

Data collected by NASA Mars missions indicate that water probably flowed across ancient Mars, but whether it exists on the surface today is a topic of debate. However, a new sequence of images taken by the Mars Reconnaissance Orbiter (MRO) show linea—narrow, dark streaks on steep slopes—that appear and incrementally grow during warm seasons and fade in cold seasons, indicating that they are formed by liquid water moving down-slope on or near the surface.

The linea extend down from bedrock outcrops, with hundreds of them forming in some rare locations. They appear and lengthen in the late southern spring and summer, when peak surface temperatures range from approximately 250 to 300 kelvin (-10 to 80 degrees Fahrenheit). Liquid brines near the surface might explain this activity, but researchers do not understand the exact mechanism and source of water. This work is important to NASA's objective to understand the processes that determine the history and future of habitability of Mars. (Read more on this story.)



Recurring slope linea do not appear in late winter (first from left). By early spring (second), the slope shows the beginning of the linea, visible as dark parallel lines. Mid-summer (third) shows dramatic, high-contrast linea, which begin to fade in the fall (forth, on the right). (Credit: NASA/JPL-Caltech/Univ. of Arizona)

### *Firsts beyond the solar system: planet orbiting two suns and a carbon-rich planet*

The existence of a world with a double sunset, as portrayed in the film *Star Wars* more than 30 years ago, is now a scientific fact. NASA's Kepler mission has made the first unambiguous detection of a circumbinary planet—a planet orbiting two stars—200 light-years from Earth. Unlike *Star Wars*' Tatooine, the planet is cold, gaseous, about the size of Saturn and not thought to harbor life, but its discovery demonstrates the diversity of planets in the Milky Way galaxy. Kepler detected the planet, officially known as Kepler-16b, by observing transits, where the brightness of a parent star dims from the planet crossing in front of it. The parent stars are smaller than Earth's Sun. One is 69 percent the mass of the Sun and the other only 20 percent. Kepler-16b orbits around both stars every 229 days, similar to Venus' 225-day orbit, but lies outside the system's habitable zone, where liquid water could exist on the surface because the stars are cooler than Earth's Sun. Kepler's mission is to search for Earth-sized planets in or near habitable zones. (Read more about this story.)

NASA's Spitzer Space Telescope observed a huge, searing-hot planet, orbiting a single star, loaded with an unusual amount of carbon. The planet, a gas giant named WASP-12b, is the first carbon-rich world ever observed. Carbon is a common component of planetary systems and a key ingredient of life on Earth. None of the planets in Earth's solar system is known to have more carbon than oxygen, though this ratio is unknown for Jupiter, Saturn, Uranus, and Neptune. Unlike WASP-12b, these planets harbor water—the main oxygen carrier—deep inside their atmospheres, making the oxygen hard to detect and quantify. WASP-12b has excess carbon, some of which is in the form of atmospheric methane. Curiously, the parent star itself has a carbon-to-oxygen ratio that is similar to that of the Sun. How the planet became enriched in carbon relative to its parent star is an unsolved mystery that NASA will investigate as it continues to pursue the objective to generate a census of extrasolar (beyond the solar system) planets and measure their properties. (Read more about this story.)

## Strategic Goal 3: Create the innovative new space technologies for our exploration, science, and economic future.

NASA's technology development programs advance mission capabilities and effectiveness, enable scientific discovery, and improve the capabilities of other government agencies and the aerospace industry. NASA's work toward achieving this strategic goal addresses three categories of technology investments that will span the technology readiness level (TRL) spectrum.

The first set of technology investments focuses on fostering early-stage innovation in which a multitude of concept technologies are developed through a process of idea generation, research, innovation, and experimentation.

The second category focuses on taking the best low-TRL technologies (those studied under the first category) and determining which of these potentially "game changing" innovations and technologies are viable through further technology development, prototyping, experimentation, testing, and demonstrations.

The third type of technology investment supports technology development targeting near-term, unique spacecraft or mission needs. Through focused studies, dialogue, and development activities across NASA, as well as with academia and industry, these technology activities will provide improved future technologies that are closely aligned with known requirements.

### *NASA's new Space Technology Program gets off to a great start*

In FY 2011, the Office of the Chief Technologist (OCT) inaugurated its Space Technology Program portfolio, which focuses on developing and demonstrating advanced space systems concepts and technologies to enable NASA's missions. Below are some of the accomplishments from the first year.

In 2008, Congress directed the National Academies to conduct a review of the effectiveness of the NASA Institute for Advanced Concepts (NIAC), which served Agency needs from 1998 to 2007. Based on the National Academies' recommendations and the results of an October 2009 hearing by the U.S. House of Representatives Subcommittee on Space and Aeronautics, NASA re-established NIAC—now called the NASA Innovative Advanced Concepts Program. During the fiscal year, NIAC made its first 30 awards for early investments and partnerships with creative scientists, engineers, and citizen inventors from across the Nation. These investments have the potential to pay huge technological dividends and help maintain America's leadership in the global technology economy. (Read more about the selected 30 proposals.)

NASA conducted the Green Flight Centennial Challenge, created to inspire the development of more fuel-efficient aircraft and spark the start of a new electric airplane industry. The winning teams, which were both electric powered, shattered the fuel efficiency requirement by achieving about twice the required passenger miles per gallon. NASA has awarded the largest prize in aviation history to the first place team, which developed an electric-powered aircraft that flew 200 miles using a little over a half-gallon of fuel equivalent per passenger.

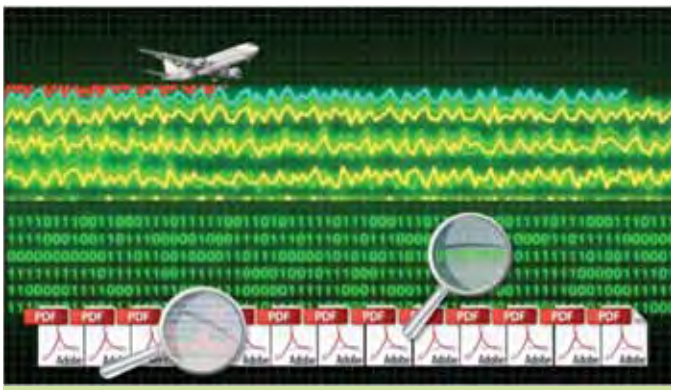
NASA implemented a Space Act Agreement with the Colorado Association for Manufacturing and Technology (CAMT) in December 2010 to promote the commercialization of technology developed for the space program through the creation of a Technology Acceleration Program and Regional Innovation Cluster for Aerospace and Clean Energy. The NASA–CAMT partnership will help companies bridge the gap between prototype design, manufacturing, and commercialization, while identifying commercial applications for NASA technologies. (Read more about this story.)

NASA Deputy Administrator Lori Garver (front right) and Elaine Thorndike, chief executive officer of CAMT sign historic Space Act Agreement at the Colorado State Capitol Building in Denver to promote the commercialization of technology developed for the space program. (Credit: NASA)

In the area of Crosscutting Capability Demonstrations, NASA selected three Technology Demonstration Missions projects to transform space communications, deep space navigation, and in-space propulsion capabilities. These crosscutting flight demonstrations—a space solar sail, a deep space atomic clock, and a space-based optical communications system—have potential to provide tangible, near-term products and to infuse high-impact capabilities into NASA's future space operations missions and other U.S. government and commercial space activities. (Read more about the selections.) NASA made key steps to foster the development of the commercial reusable suborbital transportation industry in August 2011, an important step in the longer-term path that envisions suborbital reusable launch vehicles evolving to provide the Nation with much lower-cost, more frequent, and more reliable access to orbital space. NASA selected seven companies to integrate and fly technology payloads on their commercial suborbital reusable platforms, which will carry payloads near the boundary of space. NASA will draw from this pool of commercial space companies to deliver payload integration and flight services as part of the Flight Opportunities Program. (See the list of chosen providers.) Through this catalog approach, NASA is moving toward the goal of making frequent, low-cost access to near-space available to a wide range of engineers, scientists and technologists. The government's ability to open the suborbital research frontier to a broad community of innovators will enable maturation of the new technologies and capabilities needed to enhance future activities in space.

## Strategic Goal 4: Advance aeronautics research for societal benefit.

A key enabler for American commerce and mobility, U.S. commercial aviation is vital to the Nation's economic well-being. NASA's aeronautics research contributes significantly to air travel innovation by exploring early-stage concepts and ideas, developing new technologies and operational procedures through fundamental research, and demonstrating the potential of promising new vehicles, operations, and safety technology in relevant environments. To achieve this strategic goal, NASA focuses on the most appropriate cutting-edge research and technologies to overcome a wide range of aeronautics challenges for America's current and future transportation system.



A NASA data mining algorithm allows analysts to probe an extensive repository containing different data types, including continuous and discrete flight data and text records. Subject matter experts can take a closer look at any anomalous sequences detected by the algorithm to determine if a possible safety issue exists. (Credit: NASA)

### *NASA supports safer flight operations*

Anomalous flights contain data points that are significantly different from other comparable flights. These events, known as anomalies, could be a pilot configuring the airplane for landing (setting flaps and gear) at an inappropriate time, excessive maneuvering close to the ground, or unexpected readings from an airplane system. Anomalies may signify operationally significant events that can have a potential impact on flight safety. However, they are contained within massive data sets and it would be too time consuming for human analysts to find them without support from highly capable algorithms. NASA's Aviation Safety Program is developing data mining algorithms that will detect anomalous flights from within these large datasets, helping analysts identify potential safety issues and conduct targeted studies. Currently when an algorithm detects a statistically significant anomaly, a human subject matter expert reviews the event to determine if it is operationally significant. This step ensures that a potential issue discovered by the algorithm could actually affect flight safety. If an analyst confirms a possible problem, an airline may consider multiple mitigation paths to prevent it from recurring or minimize its safety impact.

This fiscal year, the Aviation Safety Program developed an algorithm that incorporates the novel approach of concurrently considering three different data types: discrete (event-driven), continuous, and text records. The goal is to develop data-driven anomaly detection algorithms that can quickly identify the anomalous flights to narrow the analyst's attention to those relatively few flights that could contain operationally significant anomalies. The algorithm, developed as part of this work, is able to perform this task by using flight-recorded data and, when available, associated text reports. Flight recorders provide discrete variables—typically representing pilot-controlled inputs such as flap position and warnings such as low oil pressure—and continuous variables—usually representing measurements such as altitude, airspeed, and vertical speed. The text reports are provided by pilots, cabin crew, or others associated with the flight, and typically discuss problems that occurred during the flight. The algorithm is scalable, and therefore, can be supplied with a large volume of flight data.

So far, the Aviation Safety Program has tested up to 177,000 flights, using data supplied by industry partner EasyJet. Based on indications provided by the French aerospace research agency, ONERA, and by a retired pilot who provides consultation, they identified three types of operationally significant anomalies present in the flight data. The Aviation Safety Program also found that the new algorithm improved significantly upon a prior algorithm, identifying all anomalies previously identified, as well as several additional operationally significant anomalies, including altitude deviation, flap speed exceedance, and unstable approach. Additionally, the new algorithm's execution time was no more than five percent greater than the execution time of an earlier algorithm, so the inclusion of text records does not lead to a significant execution time penalty.

Going forward, the Aviation Safety Program plans to test the algorithm on even larger datasets. In FY 2012, it will conduct a test on a large 10 terabyte file to determine whether the algorithm can still detect statistically and operationally significant anomalies. This file size is consistent with those available by commercial airlines and through the Federal Aviation Administration-run Aviation Safety Information Analysis and Sharing (ASIAS) System. As an ultimate goal, the program wants analysts to be able to mine the extensive data fields to uncover new areas of potential safety issues that the aviation safety community has not previously considered.

## Strategic Goal 5: Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.

Successful missions are enabled by mission support offices, which provide program capabilities and institutional capabilities. NASA's program capabilities, which are focused on meeting multiple complex programmatic objectives, encompass NASA-unique facilities, management of scientific and engineering workforce, and the equipment, tools, and other required resources. The institutional capabilities encompass a broad range of essential technical and non-technical corporate functions for the entire Agency, such as safety and mission assurance, security capabilities, information technologies, and human capital management.

At the newly remodeled Launch Control Center's Young-Crippen Firing Room at NASA's Kennedy Space Center, engineering directorate personnel demonstrate the recently added Space Command and Control System, which will be used for launches of future human spaceflight vehicles. In use since the Apollo era, the Firing Room was rewired and received new equipment and furnishings. (Credit: NASA/J. Grossmann)

### *Facilities for the future*

NASA's physical infrastructure is critical to enable mission success. However, numerous analyses have concluded that NASA facilities are no longer suitable to meet current and future requirements. During 2011, NASA made significant progress in identifying and implementing a strategy that will enable the Agency to evolve toward the most efficient retention, sizing, and distribution of facilities, laboratories, test capabilities, and other infrastructure consistent with NASA's missions and mandates.

Such evolution includes identifying and removing unneeded or duplicative infrastructure. NASA completed Phase I of the NASA Technical Capabilities (NTC) Assessment Task, which put into place a new process and a new database tool that will help NASA balance institutional capabilities with the needs of NASA's future missions. The process and tool enable an integrated assessment of the supply of technical capabilities across all NASA Centers with the demand for technical capabilities across all NASA programs, relating the required resources associated with a capability to program funding and workforce requirements. The value of this new approach was demonstrated at a 2011 Agency-level Technical Capability Forum, where NASA resolved a significant number of supply and demand gaps.

The NTC Assessment Task has laid the groundwork necessary for NASA to arrive at long-term facilities solutions that will preserve and provide the institutional resources needed to support NASA's evolving mission.

### *NASA buildings are green*

Kennedy Space Center rang in 2011 with the grand opening of NASA's "greenest" facility on January 20. As the new hub for fueling spacecraft on journeys to unlock the mysteries of the universe, the Propellants North Administrative and Maintenance Facility will use natural resources to power buildings and vehicles at Kennedy. More than 300 photovoltaic panels on the roof are expected to generate more energy than the facility will need, making it NASA's first net-zero facility. The new facility also will become a test bed for more environmentally friendly projects at NASA Centers by making sure every aspect is truly green.

The facility qualifies for the U.S. Green Building Council's (USGBC's) Leadership in Environmental and Energy Design, or LEED, Platinum status, which is the highest of green building certifications. That certification system is based on scores generated by a point system in which the USGBC rates construction. The construction is rated in several environmentally friendly areas, including the use of sustainable sites, materials and resources, water and energy efficiency, indoor environmental quality, and design innovation.

Part of the parking lot at the Propellants North facility is tailor-made for electric cars. The covered area features plug-in stations for electric vehicles. (Credit: NASA/F. Michaux)

In June, the Langley Research Center was pleased to find out that its new headquarters building also received a "Platinum" status—the highest rating—from the LEED program. It's the first of a planned $330 million program to replace and upgrade center facilities with the future in mind. The building, called Building 2101, had 52 points, just inside the platinum scale.

## Strategic Goal 6: Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation and contribute to a strong national economy.

NASA's missions are a natural means of interacting with the public and supporting students and teachers. Through the excitement of missions and activities, NASA helps stimulate student interest and achievement in science, technology, engineering, and mathematics (STEM) fields. STEM-focused educators use their skills to motivate student achievement and spur creative and critical thinking both in and out of the classroom. In developing student interest and skills, future workers will be prepared to solve technical challenges that benefit the Nation and improve the quality of life on Earth. Furthermore, an American public that is knowledgeable and interested in science, aeronautics, and exploration will value the impact of advances in these fields that help maintain global competitiveness and a robust economy.

To achieve this strategic goal, NASA Education and the Office of Communications partner with the mission directorates and offices within the Mission Support Directorate, other government agencies, non-profit organizations, academia, and industry.

### *Education Design Team recommendations set the course for the future of NASA education*

After several months of intense effort this fiscal year, the Education Design Team (EDT) completed its mission in January 2011 by issuing its final report. The EDT report contained several recommendations for the development of a new, sustainable, and innovative science, technology, engineering, and mathematics (STEM) education program at NASA. Once implemented, these recommendations will enable NASA to do its part to ensure there are highly educated students in the Nation's STEM pipeline, allowing the United States to compete, prosper, and be secure in the 21st century global community (read report PDF).

Chartered by the NASA Administrator and deputy administrator, the EDT was composed of 12 members chosen from the Office of Education, mission directorates, mission support offices, and Centers based on their depth of knowledge and education expertise. The EDT charter called for an evaluation of the Agency's education programs within the context of current trends in education.

In July, NASA celebrated the 25th anniversary of its longest running internship program, the Langley Aerospace Research Summer Scholars (LARSS) project. As part of the celebration, interns toured facilities at Langley Research Center, including the wind tunnel shown here. LARSS helps to preserve U.S. leadership in aeronautics and space science by producing a well-educated, well-trained, and diverse engineering and science workforce. LARSS has served as a first-of-its-kind model for internship, mentoring, and development programs at other NASA centers and was recently ranked sixth on the list of "10 Best Internships for 2011" by Vault Career Intelligence. (Credit: NASA)

The EDT used a systems design approach, using top-level requirements to analyze all parts of the existing NASA education system to identify opportunities for improvement. By taking into account national education priorities and goals, Administration guidance, Congressional direction, as well as insight from nationally recognized education experts, the EDT critically evaluated NASA's existing education efforts. The resulting outcome was six recommendations intended to improve the impact of NASA's Education Program. The EDT's three programmatic recommendations were:

- Focus the NASA Education Program to improve its impact on areas of greatest national need.
- Identify and strategically manage NASA Education partnerships.
- Participate in national and state STEM education policy discussions.

Their three organizational recommendations were:

- Establish a structure to allow the Office of Education, Centers, and mission directorates to implement a strategically integrated portfolio.
- Expand the charter of the Education Coordinating Committee to enable deliberate education program design and evaluation.
- Improve communication to inspire learners.

Since the acceptance of the EDT recommendations by the NASA associate administrator for Education in February 2011, multiple cross-Agency teams comprised of education stakeholders, including representatives from the Headquarters Office of Education, Center Education offices, and mission directorates, have been aggressively working to develop an implementation plan. The EDT's recommendations have provided a foundation for improving NASA's educational offerings, which will allow the Agency to play a leading role in inspiring student interest in STEM disciplines through its unique workforce, facilities, research and innovations.

# Verification and Validation of NASA's Performance Information

Verification and validation processes ensure that performance goals are measurable, with a direct connection to an Agency's mission, and that performance data is accurate, complete, consistent, and current. NASA has verified and validated that the Agency's mission directorates and mission support offices have procedures in place for collecting, maintaining, and processing accurate performance data and can assure Congress and the public that reported performance information is credible.

Each mission directorate, including each office within the Mission Support Directorate and the Office of Education, has a process in place for assessing performance and assigning ratings to their performance goals and annual performance goals. Program officials submit to NASA management the supporting performance information that justifies each rating in accordance with NASA's internal quarterly performance reporting process. NASA conducts additional reviews and evaluations of reported performance data to assess whether the information submitted is consistent with information reported at other internal reviews, or assessments by external independent entities, and complete enough to portray an accurate picture of NASA's performance. This annual performance reporting and verification process culminates in this report.

# Financial Results

This section analyzes and discusses NASA's Financial Statements and its stewardship of the resources provided to NASA by Congress to carry out its mission. The Financial Statements, which present the results of NASA's operations and financial position, are the responsibility of NASA's management.

NASA's financial statements and accompanying notes are presented in their entirety in the Financials section (see page 191). NASA prepares the Consolidated Balance Sheet, Consolidated Statement of Net Cost, Consolidated Statement of Changes in Net Position and Combined Statement of Budgetary Resources, which provide the financial results of operations. This overview focuses on the key information provided in the statements, which describes NASA's stewardship of the resources provided to it by Congress to carry out its mission.

## Financial Highlights

### Results of Operations

NASA's net cost of operations for FY 2011 was $18.6 billion, a decrease of $2.7 billion, or thirteen percent compared to FY 2010. This decrease primarily represents reduced activity in FY 2011 for the International Space Station (ISS) and Space Shuttle Program (SSP). Most of NASA's Research and Development and Other Initiatives (R&D/Other) emphasized programs are essential to achieving various strategic goals.

NASA's programs and activities are carried out through four R&D/Other initiatives: Aeronautics Research, Exploration Systems, Science, and Space Operations. The Consolidated Statement of Net Cost presents NASA's net costs by R&D/Other initiatives, which is summarized in the table below. The net cost of operations is the gross cost incurred by NASA, less any earned revenue for work performed for other government organizations and the public.

Science and Space Operations initiatives had the largest net costs in FY 2011 at $6.0 billion and $7.2 billion, respectively. The accompanying table provides net cost comparisons for FY 2011 and FY 2010 across the four major initiatives.

## Cost by Research and Development and Other Initiatives

(In Millions of Dollars)

| R&D/ Other Initiatives | Audited 2011 | Audited 2010 | % Change |
|---|---|---|---|
| **Aeronautics Research** | | | |
| Gross Costs | $ 808 | $ 816 | -1% |
| Less: Earned Revenue | 119 | 119 | 0% |
| Net Costs | 689 | 697 | -1% |
| **Exploration Systems** | | | |
| Gross Costs | 4,791 | 5,360 | -11% |
| Less: Earned Revenue | 68 | 62 | 10% |
| Net Costs | 4,723 | 5,298 | -11% |
| **Science** | | | |
| Gross Costs | 7,030 | 6,697 | 5% |
| Less: Earned Revenue | 1,019 | 649 | 57% |
| Net Costs | 6,011 | 6,048 | -1% |
| **Space Operations** | | | |
| Gross Costs | 7,253 | 9,694 | -25% |
| Less: Earned Revenue | 58 | 429 | -86% |
| Net Costs | 7,195 | 9,265 | -22% |
| **Net Cost of Operations** | | | |
| Gross Costs | 19,882 | 22,567 | -12% |
| Less: Earned Revenue | 1,264 | 1,259 | 0% |
| Net Costs | **$ 18,618** | **$ 21,308** | -13% |

A significant portion of the decrease in net costs relates to general costs for goods and services used in operations across NASA programs, with the majority for the ISS. Remaining costs are allocated to R&D/Other initiatives.

**Aeronautics Research** net cost decreased one percent in FY 2011. The Fundamental Aeronautics and Aviation Safety programs decreased. These costs were primarily offset by the Integrated Systems Research Program costs that increased. The Integrated Vehicle Health Management project was realigned with the Aviations Safety program to improve programmatic content.

**Exploration Systems** net cost decreased eleven percent from FY 2010 to FY 2011 primarily due to a decrease in costs related to the Constellation Systems Program. This decrease was somewhat offset by an increase in costing by the commercial crew and cargo development programs, which is consistent with the transition to the new human space flight directions, and the start-up phase of the new programs.

**Science net** cost decreased one percent in from FY 2010 to FY 2011. This change primarily reflects increased revenue in the Earth Science Geostationary Operational Environmental Satellite project and reimbursable authority for the Joint Polar Satellite System. These increases in net cost were partially offset by a decrease in the Polar Operational Environmental Satellite (POES) project.

**Space Operations** net cost decreased twenty-two percent from FY 2010 to FY 2011. This is primarily due to the completion of the operational phase of the Space Shuttle Program (SSP), the transition and retirement of the program elements, and the assembly of the U.S. portions of the International Space Station (ISS), consistent with the transition to the new human space flight directions.

# Sources of Funding

NASA receives funds to support its operations primarily through Congressional appropriations. NASA's budgetary resources for FY 2011 totaled $21.3 billion, of which $615 million is the unobligated balance brought forward from FY 2010. NASA's source and use of budgetary authority is summarized in the table below.

### NASA Budgetary Resources
(In Millions of Dollars)

| Line Item | Audited 2011 | Audited 2010 | % Change |
|---|---|---|---|
| New Budget Authority | $ 18,449 | $ 18,725 | -1% |
| American Recovery and Reinvestment Act | — | 4 | -100% |
| Unobligated Balance Brought Forward | 615 | 1,320 | -53% |
| Other Resources | 2,252 | 1,460 | 54% |
| **Total Budgetary Resources** | **$ 21,316** | **$ 21,509** | **-1%** |
| Total Obligations Incurred | 20,639 | 20,894 | -1% |
| **Total Unobligated** | **$ 677** | **$ 615** | **10%** |

**New Budget Authority** which represents eighty-seven percent of NASA's total budgetary resources for FY 2011, was provided by Congress primarily through two-year appropriations. The Agency's funding appropriations decreased by $276 million, which included a rescission of $37 million.

**Other Resources** include realized reimbursable income for sharing NASA technology and providing services to other Federal agencies and public entities, and recoveries of budgetary resources that were obligated in a previous year. Other Resources increased by fifty-four percent in FY 2011 primarily for work performed for certain satellites, Geostationary Operations Environmental Satellite, and Polar Operations Environmental Satellite projects.

**Obligations Incurred** represents NASA's use of $20.6 billion of available budgetary resources to accomplish the Agency's goals within its four R&D/Other initiatives. Obligations Incurred decreased by one percent between FY 2011 and FY 2010. The reduction in obligations for appropriated funds was due to a decrease in the Agency's appropriations in FY 2011.

# Balance Sheet

## Assets

Total assets as of September 30, 2011 were $19.3 billion, an increase of $1 billion compared to September 30, 2010. The major categories of assets are detailed in the table below.

### NASA Assets
(In Millions of Dollars)

| Line Item | Audited 2011 | Audited 2010 | % Change |
|---|---|---|---|
| Property, Plant & Equipment | $ 9,840 | $ 9,635 | 2% |
| Fund Balance with Treasury | 9,395 | 8,601 | 9% |
| Other | 107 | 92 | 16% |
| **Total Assets** | **$ 19,342** | **$ 18,328** | **6%** |

NASA's largest category of assets is **Property, Plant and Equipment (PP&E)**, which increased two percent or $205 million in FY 2011. This increase is due to an increase in activity for certain satellites with the Air Force programs.

**Fund Balance with Treasury (FBWT)** represents NASA's cash balance at the Department of Treasury. FBWT increased by nine percent or $794 million.

**Other** includes investments of $17 million and Accounts Receivables of $90 million in FY 2011. Accounts Receivable increased by $19 million and primarily relating to billings due for certain satellites with the Air Force programs to replenish the aging fleet of communications spacecraft in the space network.

## Liabilities

Total liabilities as of September 30, 2011 were $4.6 billion, an increase of $336 million compared to September 30, 2010. The major categories of liabilities are detailed in the table below.

### NASA Liabilities
(In Millions of Dollars)

| Line Item | Audited 2011 | Audited 2010 | % Change |
|---|---|---|---|
| Accounts Payable | $ 1,530 | $ 1,462 | 5% |
| Other Liabilities | 1,623 | 1,755 | -8% |
| Environmental and Disposal Liabilities | 1,445 | 1,041 | 39% |
| Federal Employee and Veteran's Benefits | 51 | 55 | -7% |
| **Total Liabilities** | **$ 4,649** | **$ 4,313** | **8%** |

**Accounts Payable**, which represents amounts owed to other entities for goods and services received, increased by $68 million in FY 2011. This is due to an increase in liabilities for certain satellites and the Mars Science Lab projects.

**Other Liabilities** represents estimated contractor costs incurred but not yet paid, as well as contingent liabilities for litigation claims, accrued payroll and related costs; which decreased by $132 million. The reduction is due to lower estimated contractor costs for Space Shuttle Program activity in FY 2011 compared to FY 2010. The Space Shuttle was retired in FY 2011. Other liabilities relating to employee payroll were also lower due to less days of payroll accrual in FY 2011 compared to FY 2010.

**Environmental and Disposal Liabilities** are estimated cleanup costs for actual or anticipated contamination from waste disposal methods, leaks, spills, and other NASA activity that created, or could create, a public health or environmental risk, and cleanup costs associated with the removal, containment, and/or disposal of hazardous wastes or material and/or property. In FY 2011, NASA recorded an additional $404 million dollars of environmental and disposal liabilities to reflect the estimated total cost of environmental cleanup on known hazardous conditions bringing the total to $1,445 million, which includes anticipated cleanup at disposal for Space Shuttle and PP&E. The amount recorded in FY 2010 was $1,041 million. The majority of the increase is due to changes in individual project estimates and additional liabilities from disposal-related cleanup costs for PP&E.

**Federal Employee and Veteran Benefits** are amounts that the Department of Labor estimates on behalf of NASA for future worker's compensation liabilities for current employees. The estimate for future worker's compensation benefits includes the expected liability for death, disability, medical and miscellaneous costs for approved compensation cases, plus a component of claims incurred but not reported.

## Net Position

Net Position is comprised of both Cumulative Re¬sults of Operations (CRO) and Unexpended Appropriations and increased by $678 million as compared to FY 2010.

### NASA Net Position
(In Millions of Dollars)

| Line Item | Audited 2011 | Audited 2010 | % Change |
|---|---|---|---|
| Unexpected Appropriations | $ 6,528 | $ 5,706 | 14% |
| Cumulative Results of Operations | 8,165 | 8,309 | -2% |
| **Total Net Position** | **$ 14,693** | **$ 14,015** | **5%** |

**Unexpended Appropriations** were higher by fourteen percent or $822 million in FY 2011 due to lower Appropriations Used primarily resulting from limited budget funding under the Continuing Resolution (CR), during FY 2011, which resulted in less disbursements and the delay of procurements.

**Cumulative Results of Operations** were lower by two percent or $144 million in FY 2011. During FY 2010 NASA adopted a change in accounting principle which reduced the FY 2011 beginning balance of the CRO by $2.0 billion. This decrease was offset by a change in the Net Cost of Operations and Total Financing Sources of $1.9 billion in FY 2011.

Fiscal Year 2011

# Systems, Controls, and Legal Compliance

## Management Assurances

### Administrator's Statement of Assurance

November 15, 2011

NASA management is responsible for establishing and maintaining effective internal control and financial management systems that meet the objectives of the Federal Managers' Financial Integrity Act (FMFIA), as well as related laws and guidance. NASA is committed to a robust and comprehensive internal control program. We recognize that ensuring the effective, efficient, and responsible use of the resources that have been provided to the Agency is not only good stewardship, but also the right approach to maximizing our progress toward the realization of our goals. Within the Agency, I have made it clear that I am responsible for establishing and maintaining a sound system of internal control. In turn, I have made these responsibilities clear to my program management, mission support offices, and Center management—and they have communicated this responsibility to their subordinates. As a result, managers and employees throughout the Agency are active on a daily basis in identifying or updating key control objectives, assessing risks, implementing controls or other mitigating strategies, conducting reviews, and taking corrective actions as necessary.

NASA conducted its assessment of the effectiveness of internal control over operations and compliance with applicable laws and regulations in accordance with Office of Management and Budget (OMB) Circular A-123, Management's Responsibility for Internal Control. Based on the results of this evaluation, NASA can provide reasonable assurance that its internal controls over the effectiveness and efficiency of operations and compliance with applicable laws and regulations as of September 30, 2011, were operating effectively and no material weaknesses were found in the design or operation of the internal controls. NASA is also in conformance with Section 4 of FMFIA.

In addition, NASA's Office of the Chief Financial Officer (OCFO) performs an annual self-assessment review of the effectiveness of internal controls over financial reporting in compliance with OMB Circular A-123, Appendix A, "Internal Control Over Financial Reporting." During the current year, no material weaknesses were identified in the design and operation of internal controls over financial reporting. Accordingly, NASA makes an "unqualified statement of assurance" that its internal controls over financial reporting as of June 30, 2011, were operating effectively.

In accordance with the requirements of the Federal Financial Management Improvement Act (FFMIA), management is responsible for reporting on its implementation and maintenance of financial management systems that substantially comply with federal financial management systems requirements, applicable federal accounting standards, and the U.S. Government Standard General Ledger at the transaction level. I am pleased to report that NASA's financial management systems are in substantial compliance with the requirements of FFMIA as of September 30, 2011.

NASA will continue its commitment to ensuring a sound system of internal control exists over operations, financial reporting and compliance with laws and regulations.

Charles F. Bolden, Jr.
Administrator

# Detailed Performance

Photo, previous page: NASA engineer Ernie Wright looks on as the first six flight ready James Webb Space Telescope primary mirror segments are prepped to begin final cryogenic testing at NASA's Marshall Space Flight Center. (Credit: NASA/D. Higginbotham)

Fiscal Year 2011

# Detailed Performance

## Measuring NASA's Performance

NASA's Strategic Plan established a top-level performance framework of strategic goals, multi-year outcomes, and objectives. Every year, NASA releases a performance plan with performance goals and annual performance goals (APGs) that support this performance framework. At the end of the fiscal year, NASA reports on the progress made toward achieving its strategic goals in the Performance and Accountability Report (PAR), which is the compilation of the Agency's annual financial report and annual performance report. This section of the PAR provides detailed information on NASA's performance and is the main content for the annual performance report.

As outlined in the Management Discussion and Analysis section, in FY 2011, NASA rated 108 two- to five-year performance goals, including the five high priority ones, and 149 APGs under a new performance framework and newly revised rating criteria.

Prior to rating these measures, the FY 2011 Performance Plan was updated to reflect changes due to both Congressional budget action and to correct inaccuracies found in several measures, which were not found prior to the measures' provision in NASA's FY 2012 budget submission to the Congress.

## A Reader's Guide to NASA's Detailed Performance Data

This narrative provides a guide to the detailed information on NASA's performance found in this section. The changes to NASA's performance plan are discussed prior to provision of the progress against high priority performance goals (HPPGs) and each strategic goal by outcome. The section culminates with a discussion of the Agency's performance issues and plans for addressing these.

### *FY 2011 Performance Plan Update*

In FY 2011, the Agency updated its performance plan to adjust for funding shifts and inaccuracies found in the measures. These updates are discussed by each individual measure that was either changed or eliminated from the FY 2011 Performance Plan.

### *NASA's FY 2011 Progress Against the High Priority Performance Goals*

NASA's detailed performance data begins with a discussion of NASA's HPPGs in the areas of Earth science, aeronautics, energy management, and space operations. The performance toward this important set of goals is displayed, and information is provided for the reader to understand the rating provided for that HPPG.

### *Detailed Performance Against NASA's Strategic Goals*

NASA's detailed performance data, including how each measure was or was not met, is discussed and displayed by strategic goal. For additional information, reference A New Strategic Plan and Performance Framework section of Management's Discussion and Analysis (see page 15) for background on NASA's performance framework and the link between strategic goals, outcomes, objectives, performance goals, and annual performance goals. All data in this section is provided aligned to that framework.

### Strategic Goals

Each strategic goal section introduces the reader to the key programs or offices that support the goal and highlights key milestones completed this year. In addition, the section briefly explains the benefits and risks to achieving the strategic goals. The benefits narrative explains the value of work toward the strategic goal, from gains within the Agency to benefits for academia, the public sector, and government. Risk assessments are a regular part of NASA's review process. NASA outlines and describes the primary risks facing management, as they may affect achievement of that strategic goal and the programs that contribute to it.

### Outcomes

Each strategic goal is supported by multiple outcomes, which link the strategic goals to nearer-term targets in the two- to five-year timeframe (performance goals) and for the fiscal year itself (APGs). Each of these sections describes the value of the outcome in reaching the Agency's long-term strategic goal. NASA focuses on a selection of invaluable activities completed in the year. Discussion of these activities demonstrate how NASA met its performance or, in some cases, where it had a challenge.

### Performance Measure Descriptions, Ratings, and Trends

Within the outcome section are tables showing the ratings for each performance goal and APG that supports the outcome. Where a performance measure was not met, the description explains what factors contributed to NASA not meeting that targeted performance.

Each performance goal is a multi-year performance target designed to support the overarching strategic goal. HPPGs, which are a sub-set of these measures, are noted with the HPPG designator. While NASA rates the longer-term performance goals annually, the rating takes into account past performance, planned future work, and known risks. For this fiscal year (the first year performance goals have been a part of the performance framework), NASA has not trended performance goals across previous fiscal years.

NASA assigns ratings to the supporting APGs on an annual basis and provides the current ratings along with the previous four years' ratings to show trends in performance. NASA's APGs offer annual snapshots of progress toward a performance goal, with the exception of a sub-set of APGs designated as an efficiency measures, which directly support an outcome and cross multiple performance goals and objectives. These efficiency measures are identified as shown in the sample ratings table in the figure below.

**Sample of Annual Performance Goal (Efficiency Measure) Rating and Trending**

| Uniform and Efficiency Measures | | | | | |
|---|---|---|---|---|---|
| | FY07 | FY08 | FY09 | FY10 | FY 2011 |
| Maintain system execution time during the year-end close process at FY 2010 baseline. | None | 8IEM07 Red | 9IEM9 Red | 10IT12 Green | AMO-11-23 Green |
| | | | | | |

## *Performance Improvement Plans*

This section presents additional detail on trends in the causes of performance shortfalls at NASA and the corrective actions the Agency will take to address the shortfall. In FY 2011, NASA identified categories in which performance trends were seen for measures from both FY 2010 and FY 2011 where targets were not met. The Performance Improvement Plans explain these trends for context and discuss past actions that may have been taken to address the shortfalls. Additionally, they provide a detailed corrective action plan for each FY 2011 APG. See Performance Improvement Plans Introduction on page 155 for more information.

## Changes to the FY 2011 Performance Plan

At NASA, changes to an annual performance plan usually are caused by a combination of impacts due to funding shifts and the dynamic nature of research and development. Each budget request contains the annual performance plan that was committed to Congress for the funds requested. When the appropriation differs from the amount requested, or if Congressional direction places a different emphasis on programs than was requested by the Agency, those actions result in an update to the annual performance plan. Additionally, the dynamic nature of research and development can lead to shifting priorities, and the activities that were called out in the annual performance plan may no longer be pursued by NASA.

NASA's policy has been to allow programs to take one of the following actions if they are impacted by Congressional budget action via an appropriations or authorization law:

- Eliminate the performance measure (do not rate the performance measure);
- Change the targeted performance (rate at the new target); or
- Move the measure to the next year's annual performance plan (do not rate until the following year).

In FY 2011, three APGs were significantly impacted as a result of the year-long continuing resolution (CR). However, none of the longer-term performance goals were impacted. The NASA Authorization Act of 2010 was already factored into the FY 2011 Performance Plan prior to inclusion in NASA's FY 2012 Budget Estimates and, therefore, did not impact NASA's targeted performance. The three measures and the changes to the annual performance plan due to the year-long CR are outlined in the table below.

### Summary of FY 2011 Annual Performance Goal Changes

| Measure | Budget Account/Program | Performance Plan Change |
|---|---|---|
| APG 3.2.2.1: ST-11-8: Initiate development of at least one new technology with game changing potential for small satellites. | Space Operations/Space Technology Program | NASA did not release the solicitation and ensuing award for the Franklin Small Satellite System Technologies Program based on receiving funding less than the FY 2011 President's Budget Request levels. NASA does not anticipate pursuing this activity in FY 2012. |
| APG 3.2.2.1: ST-11-9: Initiate at least one new small satellite mission that will demonstrate game changing or crosscutting technologies in space. | Space Operations/Space Technology Program | The release of the solicitation and ensuing awards for the Edison Small Satellite Demonstration Mission were delayed based on funding less than the FY 2011 President's Budget Request levels. |
| APG 3.4.1.5 : ST-11-17: Develop an Agency technology portfolio database to track technology investments and create space technology roadmaps that prioritize these investments. | Space Operations/Space Technology Program | This measure has been moved to the FY 2012 Performance Plan. The requisite contract awards could not be made in time to complete the work associated with this measure due to the delay in the funding for the space technology programs as a result of the year-long CR. NASA made progress and successfully conducted an Agency-wide technology tracking system survey, identified existing databases, collected data from existing databases, defined hardware and software requirements, coordinated system development meetings, awarded contracts, and initiated code development. However, since the funds were not available for contract award until late summer, insufficient time was left to complete the development of the new database. NASA expects to complete this work in FY 2012. |

NASA generally rates a performance goal or APG White if there is a decision by the Agency to eliminate the program or the work activity during the fiscal year as a result of shifting priorities or other circumstances. In this case, the measure is not eliminated from the annual performance plan, nor is the target reduced. This fiscal year, NASA rated two measures White due to no planned work activities, as explained in the table below.

### Summary of FY 2011 Annual Performance Goals Rated White

| Measure | Mission Directorate | Rating Justification |
|---|---|---|
| APG: EFF AS-11-6: Complete all [Astrophysics] development projects within 110 percent of the cost and schedule baseline. | Science/ Astrophysics | The measure is based on the final development costs once a mission launches. Since there were no planned launches for FY 2011 in Astrophysics, the measure is not applicable to this fiscal year. |
| APG: EFF HE-11-6: Complete all [Heliophysics] development projects within 110 percent of the cost and schedule baseline. | Science/ Heliophysics | The measure is based on the final development costs once a mission launches. Since there were no planned launches for FY 2011 in Heliophysics, the measure is not applicable to this fiscal year. |

NASA found five measures in the FY 2011 Performance Plan that required correction due to inaccuracies that had not been fixed prior to the measures' provision in NASA's FY 2012 budget submission to Congress. These corrections are reflected as a change to the annual performance plan. NASA rated these measures after making the corrections. The table below details the changes NASA made to the original FY 2011 measures that are reflected in this document.

### Summary of Corrected FY 2011 Performance Measures

| Measure | Budget Account/ Program | Correction Made |
|---|---|---|
| PG 2.3.1.2: By ~~2015~~ 2017, launch at least two [Planetary] missions in support of this outcome. | Science/Planetary | The date was intended to be 2017 to accurately reflect the timeframe for launching the two missions that provide the basis for this measurement. |
| APG 3.1.1.4: ST-11-4: At least 24 percent of SBIR/STTR Phase II technology projects awarded between ~~2006-2010~~ 2004-2008 will be infused into NASA programs and projects. | Cross-Agency Support/Innovative Partnership Programs | NASA updated the measure to reflect the correct span of years used as the basis of the rating. This update covers the five-year span needed for the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) phase II work awarded in fiscal years 2004 to 2008 to complete and start into phase III. |
| APG 3.4.1.3 : ST-11-15: Greater than 35 percent of the SBIR/STTR Phase II technology projects awarded between ~~2006-2010~~ 2004-2008 will be transferred into commercial products or services. | Cross-Agency Support/Innovative Partnership Programs | NASA updated the measure to reflect the correct span of years used as the basis of the rating. This update covers the five-year span needed for the SBIR/STTR phase II work awarded in fiscal years 2004 to 2008 to complete and start into phase III. |
| APG 5.4.3.3 : SFS-11-7: Complete Deep Space Station-35 (DSS-35) Pedestal Excavation ~~and Azimuth track~~ at Canberra Deep Space Communications Complex (CDSCC) | Human Exploration & Operations/Space Communication | There was no planned Azimuth track work planned for DSS-35. (In FY 2010, NASA conducted this work on DSS-34.) NASA revised the measure to delete the Azimuth work from the text. |
| APG 5.4.1.2 : SFS-11-3: Develop processes for ~~crew~~ space transportation partner information sharing between NASA's Launch Services Program (LSP), Exploration Systems Mission Directorate (ESMD), ISS, and other government customers, including but not limited to Department of Defense (DoD). | Human Exploration & Operations/Launch Services | The reference to crew space transportation partner information sharing that would include other U.S. government agencies was incorrect, since none beyond NASA have crewed space flight. NASA's Launch Services Program partners with other government agencies on space transportation, in general. |

Additionally, NASA made a revision to the high priority performance goal (HPPG) for Earth science research, from the version provided in the FY 2011 Performance Plan, within NASA's FY 2012 Congressional Justification. This revision was necessitated make the measure consistent with the goal statement as provided on Performance.gov, and to assure the same method of measurement. This goal has been rated Red after the revision, reflected below.

| Original Measure | Revised Measure |
|---|---|
| PG 2.1.5.2 (HPPG): Study Earth from space to understand climate change, weather, and human impact on our planet by launching at least two missions by 2015. | PG 2.1.5.2 (HPPG): In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011. |

# NASA's FY 2011 Progress Toward the High Priority Performance Goals

In FY 2010, NASA developed and began reporting on five high priority performance goals (HPPGs) on a quarterly basis. In accordance with the GPRA Modernization Act of 2010 and a White House initiative for building a high-performing government, NASA's HPPGs represent challenging, near-term targets that the Agency will reach to benefit the American people in the areas of human exploration, Earth science, aeronautics research, and energy management.

**FY 2011 High Priority Performance Goal Summary**

| High Priority Performance Goal | Responsible Organization | Rating |
|---|---|---|
| PG 1.1.1.2 (HPPG): Safely fly out the Space Shuttle manifest and retire the fleet. | Human Exploration Operations, Space Shuttle Program | **Green** |
| PG 2.1.5.2 (HPPG): In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011. (Rated after revision) | Science Mission Directorate, Earth Science | **Red** (See the Performance Improvement Plan for more information.) |
| PG 4.1.2.1 (HPPG): Increase efficiency and throughput of aircraft operations during arrival phase of flight. | Aeronautics Research Mission Directorate, Airspace Systems | **Green** |
| PG 5.2.3.2 (HPPG): Conserve valuable natural resources by reducing NASA's energy and water use. | Mission Support Directorate, Environmental Compliance and Restoration | **Yellow** (See the Performance Improvement Plan for more information.) |
| PG 5.5.1.1 (HPPG): Establish an independent non-profit (NPO) organization to enhance the utilization of the ISS as a National Laboratory. | Human Exploration Operations, International Space Station | **Green** |

## Safely fly out the Space Shuttle manifest and retire the fleet.

After 30 years of space flight, more than 130 missions, and numerous science and technology firsts, NASA completed the Space Shuttle manifest with the successful return of Shuttle Atlantis on July 21, 2011, after its mission to the International Space Station (ISS). With that last flight, NASA remains on track to complete close-out activities and ultimately the HPPG.

The Space Shuttle has been essential for construction of the ISS, a multi-decade program between the space agencies of Canada, Europe, Japan, and Russia to build an advanced research and development test bed in low Earth orbit. Since 1998, NASA has dedicated 37 Shuttle flights to the assembly, outfitting, and utilization of the ISS. NASA has used an extensive network of people, facilities, capabilities, industry teams, logistics, organizations, and international partners to safely operate the Space Shuttle. NASA will transfer Space Shuttle assets that can be leveraged for use in future exploration programs and preserve key Agency technical capabilities for future use. Capabilities that are no longer needed or are obsolete will be retired. As the final step in the Space Shuttle's journeys, NASA is preparing the orbiters for display at institutions across the country to inspire the next generation of explorers and engineers. NASA has worked with each of the facilities to complete plans to transfer the orbiters throughout 2012.

In the Vehicle Assembly Building at NASA's Kennedy Space Center in Florida, workers lower the cage containing an Approach and Landing Test Assembly (ALTA) pod over the rear of Space Shuttle *Endeavour*. The ALTA pod is being attached to the site once housing the orbital maneuvering system (OMS) pod. NASA is conducting the demonstration test to ensure the Center's equipment will fit into the hangar at the National Air and Space Museum when installing an ALTA pod on Shuttle *Enterprise*. The pod must be reinstalled on a Shuttle for transport on a 747 carrier aircraft. The simulation also tests procedures and timelines necessary to carry out the process. The work is part of the Space Shuttle Program's transition and retirement processing. (Credit: NASA/J. Grossmann)

## In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011.

On September 15, 2011, technicians perform final testing on NASA's NPP satellite in a clean room at Vandenberg Air Force Base in California. (Credit: Ball Aerospace)

NASA works to gain a deeper scientific understanding of the components of the Earth system, their interactions, and the consequences of its changes for life, including effects on climate, oceans, air quality, water resources, and biodiversity that sustain life and society. NASA's Earth Science Program conceives, develops, and operates a fleet of sophisticated scientific spacecraft for Earth observation. This fleet, by making complementary key measurements, provides improved understanding of the Earth system. The NPOESS Preparatory Project (NPP) and Glory missions were the next spacecraft planned to join this fleet.

NPP will extend key climate measurements begun by NASA's Earth Observing System for the climate research and applications communities. It also will serve as an essential gap-filler, owing to delays in the development and launch of the National Polar-orbiting Operational Environmental Satellite System, or NPOESS, for the Nation's civil and military operational weather prediction efforts. Throughout FY 2011, NASA made extraordinary progress on meeting the development milestones for NPP, including preparation of the ground-based systems required to send commands to, and receive and process data from, the NPP spacecraft and instruments. The mission launched successfully on October 28, 2011, from Vandenberg Air Force Base in California.

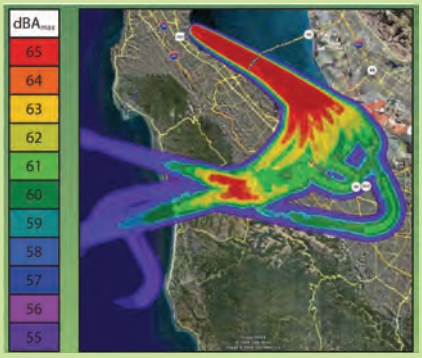
The Glory mission was designed to measure, for the first time, aerosol size, quantity, physical properties, and shape, helping researchers distinguish the relative influences of natural and human-caused aerosols on our global climate. On March 4, 2011, Glory launched from Vandenberg Air Force Base in California. The countdown and launch went smoothly until the point at which the fairing, the protective shell atop the rocket, was to separate from the vehicle. Telemetry data has indicated the fairing did not separate as expected about three minutes after launch, and the Glory spacecraft did not reach orbit.

With the unfortunate loss of the Glory mission, NASA did not meet all the milestones associated with this high priority performance goal. In response to the loss, NASA has created a Mishap Investigation Board to evaluate the cause of the failure and will use the results to determine the next steps for providing reliable mid-sized launch services for NASA science missions. The Science Mission Directorate is evaluating the loss of the mission on the long-term science objectives, and discussing the options available to keep on-track toward this performance goal. The relative priority for replacing the Glory measurements will be considered in the context of the Earth Science portfolio and all of its objectives, in the coming year.

## Research and develop new technologies to increase the flexibility and efficiency of the Nation's air traffic system.

Current air traffic control operations require an air traffic controller to generate and provide clearances manually (that include path and speeds) so that aircraft can arrive at an established point on a route, and time-regulate entry into an airport's terminal area, at a scheduled time during the arrival phase of flight. The manual process often results in inefficient paths for an aircraft's flight and descent (particularly during higher traffic density operations), restricting the number of aircraft that can be processed for arrival operations, as well as increased noise and fuel consumption.

The En Route Descent Advisor (EDA) is a tool that proposes to the air traffic controller the speed and path changes that will allow an efficient arrival profile. EDA monitors many aircraft simultaneously, maximizing throughput by ensuring that each aircraft meets its scheduled time for arrival, while avoiding flight path conflicts between aircraft. EDA's innovation includes reducing flight time, fuel consumption, noise, and emissions, thus resulting in more environmentally friendly en route and terminal operations.




**Noise footprint using existing procedures at SFO**

**Noise footprint using EDA procedures at SFO**

NASA currently is researching EDA, a tool for air traffic controllers that enables aircraft to fly a smooth and continuous descent during heavy traffic congestion to minimize fuel consumption, environmental emissions, and noise pollution. During operational trials conducted at San Francisco International Airport (SFO), flight test data showed significant noise reduction (over existing procedures shown on the left) resulting from idle-thrust descents enabled by the EDA (see right map). Red indicates the highest decibel levels and purple the lowest. (Credit: NASA)

To support the effort, NASA will provide to the Federal Aviation Administration (FAA) the demonstration results from field tests of the EDA tool. In FY 2011, NASA made great progress toward this high priority performance goal. The Airspace Systems Program conducted four human-in-the-loop simulations using the EDA tool. The final simulation conducted at the end of September 2011 was designed to document the benefits for use of the tool if widely used in the national airspace system. NASA will use these results to develop the technology transition document required by the FAA by next year, which is the next step for moving use of the technology into use in real airport operations.

## Conserve valuable natural resources by reducing NASA's energy and water use.

NASA Centers have been steadily working to reduce energy consumption and create innovative practices for energy sustainability since 2005. In the past four years, even as consumption was reduced, the unit cost of energy has increased dramatically, without offsetting budget increases. The Agency is working aggressively to implement alternative and innovative energy practices and resources to supply and to conserve energy in the operation of its facilities. NASA is seeking improvement in three major areas:

- For facility energy use, the target is 30 percent reduction in energy intensity btu/gsf (or energy per gross square foot) by the end of 2015 (from a 2003 baseline, reduce energy three percent per year for 2006–2015).
- For fleet vehicle energy use, the target is 30 percent reduction in fleet total consumption of petroleum products by the end of 2020 (two percent per year from a 2005 baseline).
- For potable water use, the target is 26 percent reduction in water intensity gal/gsf (or gallons per gross square foot) by the end of 2020 (two percent per year from a 2007 baseline).

Efforts in FY 2011 that support these goals included submitting the 2011 NASA Strategic Sustainability Performance Plan to the Office of Management and Budget, investing $48 million in energy related construction/recapitalization projects, and establishing Solar Assisted Electric Vehicle Charging Stations.

Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA expects to exceed its targets on the measures related to water use and fleet management, but fall short on the energy intensity goal, against the annual target set to meet Executive Order 13423. In FY 2011, NASA reduced energy intensity by an estimated one percent (three percent was the target), for an eight percent reduction from 2003 baseline. The rating seen for this high priority performance goal reflects not fully meeting the annual target.

To continue efforts to reduce energy consumption and improve NASA's aging infrastructure, the Agency designs and constructs new buildings to the minimum Leadership in Energy and Environmental Design Silver standard. NASA is increasing energy savings performance contracts and utility energy service contracts at various Centers and created a position at Headquarters to support the Centers with implementation and execution of these complex projects. Additionally, NASA performed an Agency survey for renewable energy project opportunities and is evaluating the final report for project identification. Projects to reduce energy intensity will be initiated per available funds. Lastly, the Agency has applied for in-kind enhanced-use leasing authority with the FY 2012 budget request to implement large renewable energy projects that could significantly reduce energy intensity.

## Establish an independent organization to enhance the utilization of the International Space Station as a National Laboratory.

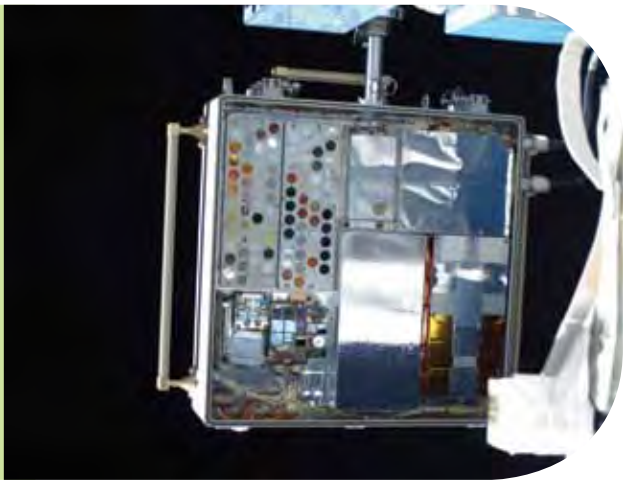
The ISS provides a multidisciplinary, cutting edge, unique research platform to pursue microgravity and engineering research and technology development test bed applications. The ISS is a critical step in developing, testing, and validating the next generation of space technologies and operational processes needed to explore beyond low Earth orbit.

Providing access to this resource to researchers outside of traditional NASA program mechanisms, as made possible by an independent non-profit organization (NPO), will encourage and enhance research and innovations to address other national priorities or concerns. Potential discoveries, particularly in the area of human health or energy technologies, could benefit future NASA missions, as well as enhance life on Earth.

On August 31, 2011, NASA signed a Cooperative Agreement with the Center for the Advancement of Science in Space (CASIS) as the independent NPO to develop and manage the U.S. portion of the ISS to be operated as a National Laboratory. With the signing of this agreement, NASA has successfully completed a significant milestone in this fiscal year and achieved the high priority performance goal.

Located at the Space Life Sciences Laboratory near the Kennedy Space Center, CASIS will be a single point of contact for U.S. (non-NASA) researchers. In addition, CASIS will be responsible for maximizing the value of the ISS by stimulating use of the ISS as a National Laboratory and developing and managing a diversified research and development portfolio for conducting basic and applied research.

This photo, taken during a July 12, 2011, spacewalk, shows the Materials on International Space Station Experiment (MISSE)-8 attached to the outside of the ISS. The experiment package is evaluating the effects of atomic oxygen, ultraviolet, direct sunlight, radiation, and extremes of heat and cold on materials and computing elements. The results of this experiment will help researchers develop new materials and computing elements that can better withstand the rigors of space environments. CASIS will have the responsibility of using the ISS' unique research facilities, including its unpressurized, exterior platforms, to develop its potential as a National Laboratory. (Credit: NASA)



Strategic Goal 1

# Extend and sustain human activities across the solar system.

Humans are driven to explore the unknown, discover new worlds, push the boundaries of scientific and technical limits, and then push further. For over 50 years NASA has been tasked with developing the capabilities that will support the country's long-term human space flight and exploration efforts. The Agency's operations have increased in complexity, and crewed space journeys have increased in duration. With the help of domestic and international partners, NASA has embarked on a steady progression of activities and milestones that has prepared the Agency for the more difficult challenges ahead—expanding permanent human presence beyond low Earth orbit. NASA will pursue this goal through strategic investments and partnerships to drive advances in science and technology. To be successful, NASA will need equal and full participation from international partners and the commercial sector, including mission-enabling contributions, support capabilities, and technologies. NASA's human spaceflight programs are responsible for keeping astronauts healthy, safe, and productive through the Agency's work in human health, life support systems and habitation, and numerous technologies for exploration in space or on another planet. Looking toward the future, NASA is developing a new Space Launch System, Orion Multi-Purpose Crew Vehicle, and ground systems to support exploration activities.

## Benefits

NASA and its international partners have sustained a continuous human presence in low Earth orbit for over a decade, transcending individual nationalism to live, work, and make discoveries in space that benefit everyone. Mission by mission, the men and women who fly aboard the International Space Station (ISS) are developing capabilities that will enable NASA to expand human space exploration across the solar system, and performing multidisciplinary, cutting-edge research that supports a broad array of biological and physical research objectives. Today, NASA is leveraging the capabilities of the commercial sector to enable robotic and human space flight as we partner with industry to develop the advanced technologies for exploration. These investments act as an economic stimulus across a broad spectrum of industries.

Expedition 27 crewmember Paolo Nespoli took this image of ISS and the docked Space Shuttle *Endeavour* (STS-134) from the Soyuz TMA-20 following its undocking on May 23, 2011. (Credit: NASA)

## Risks to Achieving Strategic Goal 1

**Advanced Technology Development.** Innovative and affordable technologies are fundamental building blocks required to safely send humans to ISS and beyond low Earth orbit. They must be pursued, developed, and matured over many years. These long timeliness pose a challenge as national priorities change and NASA shifts program focus. Currently, the human space flight programs are partnering with the Office of the Chief Technologist to enable the rapid development and testing of a broad set of prototype systems to enable future human missions. These prototype systems can be used as building blocks to construct a variety of mission systems for exploration of the Moon, near Earth asteroids, and Mars, and to provide the flexibility to adapt to new objectives in the future.

**Availability of Commercial Cargo and Crew Services.** A key factor in sustaining and operating ISS is the ability to provide crew transportation and ensure cargo resupply now that the Space Shuttle fleet is retired. NASA will continue to use the vehicles of the international partners for crew transportation, rescue, and cargo resupply as we develop additional U.S. provided capabilities.

**Affordability and Sustainability.** Exploration beyond low Earth orbit will span decades. NASA's budget requests are intended to maintain a sustainable exploration strategy to secure the long-term stability of these programs that will extend human presence into the solar system. NASA has developed an architecture that is affordable and sustainable over a long budget horizon through programs that accommodate external changes by employing innovative acquisition approaches and industry best practices. NASA will continue to focus on affordability and performance factors, and collaborate with interagency and international partners to ensure the safe execution of exploration missions beyond low Earth orbit.

The Orion Multi-Purpose Crew Vehicle makes a big splash as it hits the water during its third water landing test conducted at the Hydro Impact Basin located at NASA Langley Research Center. This test represented the worst-case scenario for landing. The prediction had a 50 percent chance of the test article getting inverted. During the tests, the Orion Project Team collected valuable data regarding Crew Vehicle stability. They also obtained invaluable experience in uprighting the test article. (Credit: NASA/S. Smith)

# Outcome 1.1

## Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.

The ISS is a major stepping stone in achieving NASA's exploration goals across the solar system. It provides a space-based research and development laboratory to safely perform multidisciplinary, cutting-edge research. The continuously crewed laboratory—the Nation's newest National Laboratory—enables the ongoing evolution of research and technology objectives and ensures that the benefits of this multinational investment can be realized.

Under the auspices of a non-profit management organization, NASA will continue to make the ISS available as a national resource to promote opportunities for advancing basic and applied research in science and technology to other U.S. government agencies, university-based scientists and engineers, and private firms. The National Laboratory management entity will be responsible for stimulating, developing, and managing a diversified research and development portfolio using the ISS to address U.S. needs.

The ISS Program completed several milestones during FY 2011, including final construction of the ISS vehicle, sustaining operations on-board, and accomplishing all on-orbit research objectives.

### *Completing construction of the ISS*

For the ISS, FY 2011 marked the final assembly of the major structure.

*Discovery* (STS-133) delivered the Italian-built Permanent Multipurpose Module (PMM). Named Leonardo, NASA used the module to ferry supplies, equipment, experiments and other cargo to and from ISS via the Space Shuttle's payload bay. Leonardo had visited the station seven times before as a cargo carrier before being refurbished to serve as a permanent 2,472 cubic-foot addition to the orbiting laboratory, providing more space and accommodations for research. Among the 6,000 pounds of Leonardo cargo was Robonaut 2, a human upper torso-like robot that could be a precursor of devices to help during spacewalks. During *Discovery*'s almost nine days at the ISS, the Shuttle crew performed two spacewalks for maintenance work and installation of new components. The ISS also received two more Express Logistics Carriers (ELCs) on STS-133 and STS-134. These unpressurized platforms attached to the exterior of the ISS that can be used for research. Both the PMM and the ELCs will provide greater space and accommodations for research to be performed on ISS.

European Space Agency astronaut Paolo Nespoli, Expedition 27 flight engineer, works with the Light Microscopy Module (LMM) in the Destiny laboratory on April 21, 2011. LMM is designed to research colloidal structures, a mixture in which one substance is divided into minute particles (called colloidal particles) and dispersed throughout a second substance. (Credit: NASA)

### *Sustaining operations on ISS*

During the fiscal year, the ISS was visited by 13 vehicles, including the final Shuttle mission, STS-135, which launched in July 2011. In all, the vehicles delivered 143,000 pounds (65,000 kilograms) of fuel, research equipment, spare hardware, and supplies, leaving the ISS well supplied and ready to support utilization activities, as well as the first commercial resupply missions.

In August, the Russian Progress 44P, loaded with fuel and supplies bound for the ISS, failed to reach orbit due to a launch vehicle failure. The ultimate impact of the 44P loss is not yet completely quantified,

but the resupply visits from the other vehicles left the ISS well prepared for the next fiscal year. The ISS was reduced to three crew members with the return of three Expedition 28 crew members on Soyuz 26S. This planned return was part of the standard six crew rotation plan, which always includes a temporary period of three crew operations. Crewed Soyuz flights will resume with the launch of 28 Soyuz on November 14, 2011, restoring the ISS back to a full crew of six.

## Conducting research aboard the ISS

NASA's research goals for the ISS are driven by the NASA Authorization Act of 2010 and are focused on four areas: human health and exploration, technology testing for enabling future exploration, basic life and physical sciences, and earth and space science. During FY 2011, the ISS Program provided 100 percent of all on-orbit resources needed to support the ISS research objectives including power, data, logistics, crew time, and accommodations.

### *Human health research and applications*

In 2011, NASA's Human Research Program (HRP) made extensive use of the ISS to perform research on maintaining human health and performance during and after long-duration space flight. HRP flew 11 major medical experiments to evaluate the immune system and other human health areas to make exploration missions healthier, safer, and more productive. HRP also added new ISS biomedical capabilities, including the second-generation ultrasound for medical imaging, the Urine Monitoring System, and the jointly developed European Space Agency (ESA)–NASA Muscle Atrophy Research and Exercise System. Additionally, HRP developed programmable lighting to aid in astronaut adaptation to the work, rest, and sleep cycle while living on the ISS.

During the fiscal year, the program delivered significant research products that will help take human space explorers far beyond low Earth orbit, such as an updated space radiation cancer risk model that predicts the lifetime cancer health risk from exposure to deep space radiation—a vital tool in planning safe exploration missions.

Under the leadership of HRP, NASA collaborated with ESA in January 2011 to develop and deploy a highly successful international outreach program called "Mission X," which brought together 14 space agencies and various partner institutions to work together to address health and fitness education for young people around the globe.

NASA lists and summarizes the experiments conducted aboard the ISS on the program's Web site at http://www.nasa.gov/mission_pages/station/research/experiments/experiments_by_expedition.html. See expeditions 25/26 (September 2010 through March 2011) and expeditions 27/28 (March 2011 through September 2011) for experiments spanning FY 2011.

### *The biological and physical sciences*

NASA's biological and physical sciences conducts openly solicited, peer-reviewed research to understand the fundamental laws of nature. This research produces foundational knowledge necessary to develop systems, like life support and radiation shielding, for the next generation of spacecraft and to reduce the risk for humans traveling in space.

The last two missions of the Space Shuttle were instrumental in enabling this research. Eight space flight experiments were conducted to characterize various effects of spaceflight on the mammalian immune system, effects of an experimental bone countermeasure on muscle and bone, and new means to reduce biofilm formation, and plant studies to characterize mechanisms of plant signaling that can help improve future strategies for plant growth in space. In addition, 43 post-flight Bio-specimen Sharing projects studied the effects of space flight on virtually all the mammalian tissue—ranging from the brain to the reproductive system—after return to Earth. The knowledge gained by these experiments have furthered researchers' understanding of how space affects living systems and also will have applications for Earth.

In accordance with the NASA Science Plan, NASA is making significant progress in the developing ISS hardware to support the flight of rodents and large plants on ISS. Finally, NASA completed and published the Space Biology Science Plan for the next decade, 2010 through 2020.

In FY 2011, NASA completed pioneering research on polymeric liquids aboard the ISS. This project, in planning since the mid-1990s, uses microgravity to examine the behavior of polymeric liquids, which include saliva, adhesives, and inks. The results of the ISS experiment will help scientists build better models of polymeric liquids, leading to improvements across a range of technologies that use polymeric liquids. Watch a video of the principle investigator explaining his experiment and demonstrating some of the interesting mechanical properties of saliva.

Other important research in completed in 2011 included the Flame Extinguishment Experiment. This research, led by internationally prominent experts in combustion research, has provided benchmark data on a fundamental element of many combustion technologies, the burning drop of liquid fuel. The results of these space experiments will contribute to models of spray combustion supporting the development of more effective fire suppression technologies in space vehicles and the design of improved combustors with greater fuel efficiency and lower emissions characteristics in systems that rely on spray combustion like diesel engines.

### *Education from space*

ISS educational activities have had a positive impact on thousands of students by involving them in ISS research, and by using the station to teach them the science and engineering that are behind space exploration. Below are some examples of ISS educational activities conducted during the fiscal year:

ISS educational activities—focusing on the K–12 classroom and designed to encourage learning and interest in science, technology, engineering, and mathematics (STEM) education—examined weaving characteristics of spiders, movement behaviors of fruit flies, and directional plant growth in response to light sources.

The Kids In Micro-G hands-on design challenge was won by two fifth grade girls from San Diego, California, who designed a study called "Attracting Water Drops" to look at static attraction in microgravity. The purpose of the challenge was to give students a hands-on opportunity to design an experiment or simple demonstration that could be performed both in the classroom and by astronauts aboard the ISS.

The Commercial Generic Bioprocessing Apparatus Science Insert experiments are educational ISS payloads designed to interest K–12 students in STEM by providing the opportunity for these students to participate in near real-time research conducted aboard the ISS. The project is managed by BioServe Technologies, in partnership with NASA, Orions Quest, Adventures of the Agronauts, Baylor College of Medicine's Center for Educational Outreach, Monarch Watch at University of Kansas, and the Denver Museum of Nature and Science.

## Outcome 1.1

Sustain the operation and full use of the International Space Station (ISS) and expand efforts to utilize the ISS as a National Laboratory for scientific, technological, diplomatic, and educational purposes and for supporting future objectives in human space exploration.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Maintain capability for six on-orbit crew members. | | | | | 1.1.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| In concert with the International Partners, maintain a continuous crew presence on the ISS by coordinating and managing resources, logistics, systems, and operational procedures. | 7ISS5 Green | 8ISS06 Green | 9ISS6 Green | 10ISS07 Green | ISS-11-1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| HPPG: Safely fly out the Space Shuttle manifest and retire fleet. | | | | | 1.1.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Release major Space Shuttle operations facilities at Kennedy Space Center for future institutional and programmatic use. | None | None | None | 10SSP04 Green | SSP-11-1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide cargo and crew transportation to support on-orbit crew members and utilization. | | | | | 1.1.1.3 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Fly the ISS elements, spares, logistics, and utilization hardware as agreed to by the International Partners to the ISS transportation plan. | 7ISS3 Green | 8ISS03 Green | 9ISS3 Green | 10ISS03 Yellow | ISS-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Maintain and operate a safe and functional ISS. | | | | | 1.1.1.4 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Provide 100 percent of planned on-orbit resources (including power, data, crew time, logistics, and accommodations) needed to support research. | None | 8ISS04 Green | 9ISS4 Yellow | 10ISS04 Green | ISS-11-3 Green |
| Achieve zero Type-A (damage to property at least $1 million or death) or Type-B (damage to property at least $250 thousand or permanent disability or hospitalization of three or more persons) mishaps. | None | None | None | 10ISS05 Green | ISS-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Advance knowledge of long-duration human space flight by establishing agreements with organizations to enable full utilization of the ISS. | | | | | 1.1.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Accomplish a minimum of 90 percent of the on-orbit research objectives as established one month prior to a given increment, as sponsored by NASA, baselined for FY 2011. | 7ISS2 Green | 8ISS02 Green | 9ISS2 Green | 10ISS02 Green | ISS-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Conduct basic and applied biological and physical research to advance and sustain U.S. scientific expertise. | | | | | 1.1.2.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop at least two life sciences flight payloads for ISS or Free Flyer platforms. | None | 8AC02 Green | 9AC3 Green | 10AC03 Green | ERD-11-1 Green |
| Deliver at least five physical sciences payloads for launch to the ISS. | None | 8AC01 Green | 9AC1 Green | 10AC01 Green | ERD-11-2 Green |
| Conduct at least five experiments in combustion, fluids or materials sciences on the ISS. | None | None | 9AC2 Green | 10AC02 Green | ERD-11-3 Green |

# Outcome 1.2

## Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.

Commercial space transportation is a vital component to the future of human space exploration. As NASA charts a new course to send humans deeper into space than ever before, it also is stimulating efforts within the private sector to develop and operate safe, reliable, and affordable commercial space transportation systems. Once the capabilities are matured and available to the government and other customers, NASA could purchase commercial services to transport crew and cargo to the International Space Station (ISS) and low Earth orbit.

NASA's Commercial Orbital Transportation Services (COTS) is an investment designed to spur development of cost-effective, U.S. commercial space transportation systems that could eventually be used to carry cargo and crew to the ISS. COTS currently funds Space Act Agreements with two partners, Space Exploration Technologies Corporation (SpaceX) and Orbital Sciences Corporation (Orbital) for the development and demonstration of cargo transportation capabilities. COTS awarded a funded Space Act Agreement to SpaceX during the initial competition in 2006 and to Orbital during the second round of competition in 2008.

During FY 2011, NASA commercial partners made progress towards accomplishing their final demonstration missions, which will include proximity operations and berthing with ISS.

SpaceX's Falcon 9 launches on December 9, 2010, from Cape Canaveral Air Force Station, next to Kennedy Space Flight Center in Florida. (Credit: SpaceX)

### *SpaceX makes history with its successful demonstration mission*

On December 8, 2010, SpaceX completed its first COTS demonstration mission. During this demonstration mission, SpaceX launched its Dragon spacecraft into orbit on its Falcon 9 launch vehicle. The Dragon completed two orbits of Earth, and became the first commercial spacecraft in history to reenter the atmosphere from low Earth orbit and splash down. Currently, the Falcon 9 launch vehicle and Dragon spacecraft are at the SpaceX launch facility at Cape Canaveral in Florida in preparation for the next COTS demonstration mission.

NASA's investments with its commercial partners are beginning to bear fruit in other ways. SpaceX reports having 30 missions on its current manifest, many of these being foreign launch customers. The COTS investment is helping the United States become more competitive in the global launch marketplace and increase its percentage of the launch market. The Nation now stands at the beginning an era of providing the best global value to both government and commercial launch customers.

### *Orbital completes milestones in preparation for maiden launch vehicle flight*

Orbital completed several milestones, preparing the company for its first Taurus II launch vehicle maiden flight and final demonstration mission. Orbital completed a cargo demonstration using a sample manifest that included physical stowage of cargo simulators in their pressurized cargo module. Orbital began launch vehicle engine acceptance testing

Orbital's Cygnus spacecraft Service Module is shown here during its development. (Credit: Orbital Sciences Corporation)

and delivered launch vehicle and spacecraft flight hardware to NASA's Wallops Flight Facility. This spacecraft flight hardware included the maiden flight launch vehicle and flight Pressurized Cargo Module (PCM) in preparation for the demonstration mission next year.

### *NASA awards second round of commercial crew development awards*

To further stimulate efforts within the private sector for the development and demonstration of safe, reliable, and cost-effective space transportation capabilities, NASA awarded approximately $270 million to four commercial companies in April 2011 and approximately $46 million in September 2011 in optional milestones.

This investment by NASA continues and expands the 2009 Commercial Crew Development (CCDev) initiative where NASA used American Recovery and Reinvestment Act funds to develop and demonstrate human spaceflight capabilities. Through this new effort, CCDev2, NASA's commercial partners will further advance commercial crew space transportation system concepts, maturing the design and development of system elements such as launch vehicles and spacecraft. These investments will spur economic growth as capabilities for new cost effective space markets are created. NASA and the nation will benefit from a reduced gap in U.S. human spaceflight capability. (Read more about the CCDev2 awards.)

### *Setting requirements for commercial services*

During the fiscal year, NASA has been developing the acquisition strategy and long term planning for investment in end-to-end commercial crew transportation capabilities. In December 2010, NASA released the Commercial Crew Transportation System requirements for NASA low Earth orbit missions, which provides a consolidated set of requirements, standards, and processes that will be applied to the certification of a specific commercial crew transportation system for low Earth orbit missions.

NASA developed a series of documentation to communicate roles and responsibilities, technical management processes supporting certification, crew transportation system and ISS services requirements, ISS interface requirements, and the application of technical and operations standards for potential commercial partners. Over the year, these documents have been reviewed within NASA and by industry. NASA's overarching strategy for the development of these documents is to ensure the requirements meet NASA safety and performance standards, yet is not overly prescriptive and allows commercial industry maximum flexibility to develop safe, reliable, and cost effective human space transportation systems.

## Outcome 1.2

Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Develop competitive opportunities for the commercial community to provide best value products and services to low Earth orbit and beyond. | | | | | 1.2.1.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Conduct a minimum of one commercial cargo demonstration flight of new cargo transportation systems. | None | None | None | 10CS08 Yellow | CS-11-1 Green |
| Conduct a minimum of one commercial cargo demonstration flight of proximity operations with ISS. | None | 8CS08 Yellow | 9CS9 Yellow | 10CS07 Yellow | CS-11-2 Yellow |
| ***Why NASA rated APG CS-11-2 Yellow:*** This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones. (See page 166 for the Performance Improvement Plan.) | | | | | |
| Conduct a minimum of one safe berthing of commercial cargo transportation systems with the ISS. | None | None | None | 10CS08 Yellow | CS-11-3 Yellow |
| ***Why NASA rated APG CS-11-3 Yellow:*** This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones. (See page 166 for the Performance Improvement Plan.) | | | | | |
| Release announcement for the development of commercial crew transportation systems (CCDev2). | None | None | None | None | CS-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop and document evaluation and certification processes for an integrated commercial crew transportation system. | | | | | 1.2.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop NASA processes and requirements required to ensure crew safety to and from the ISS and other NASA and low Earth orbit destinations. | None | None | None | None | CS-11-5 Green |

# Outcome 1.3

## Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.

Exploration beyond low Earth orbit will span decades, with the first step in embarking on this long and challenging journey involving the development of solid groundwork to ensure a successful endeavor. Experienced personnel from across the Agency are building a set of architectures, or mission frameworks, for multiple destinations in the solar system. These architectures include all aspects of mission performance—technologies, partnerships, safety, risk, schedule, and stakeholder priorities—that define the knowledge, capabilities, and infrastructure necessary to support human space exploration.

### *Team begins building a NASA architecture*

In FY 2011, NASA formed the Human Architecture Team (HAT) to further develop mission architectures that include all aspects of mission performance. HAT met weekly to share information across the Centers and focus Design Reference Mission (DRM) studies toward evolving technologies and launch vehicle architectures. HAT created 10 DRMs that capture national and international priorities for evaluation by Agency stakeholders.

Additionally, HAT provided technical support to the development and release of the Global Exploration Roadmap, an international collaboration to collect, organize and align international space agencies' high level objectives for future space exploration. The lead organization, International Space Exploration Coordination Group, released the Global Exploration Roadmap on September 23, 2011. The report can be found at http://www.nasa.gov/exploration/about/isecg/.

SLS sits on the launch pad in this artist's concept. The launch vehicle will be able to carry the Orion Multi-Purpose Crew Vehicle, as well as cargo and equipment to Earth orbit and beyond. (Credit: NASA)

## The vehicles and systems

### *NASA announces design for new deep space exploration system*

On September 14, 2011, NASA announced that it was ready to move forward with the development of the Space Launch System (SLS), an advanced heavy-lift rocket to support missions beyond low Earth orbit. The NASA Authorization Act of 2010 directed NASA to develop the SLS, and significant work was completed in FY 2011 to refine the overall vehicle architecture while continuing hardware testing. Based on an intensive series of requirements and alternatives analysis reviews, NASA chose an evolvable architecture based on hardware used on Space Shuttle and in development under the Constellation Program, including Space Shuttle Main Engines (RS-25d), Core and Upper Stage designs based on existing Space Shuttle External Tank diameters, the J-2X engine for the Upper Stage, and five-segment solid rocket boosters for the initial SLS test flights.

Representative of the extensive testing and hardware development in FY 2011 was the first set of hot fire tests of a complete J-2X engine at the Stennis Space Center and a test of a five-segment booster in Utah. NASA has shared its vision of the SLS development through the release of procurement documents at an Industry Day in Huntsville, AL on September 29, 2011.

Technicians position microphones around the Orion MPCV and launch abort system test articles in preparation for the second round of acoustic tests. More than 600 instruments, 500 accelerometers and 100 microphones were placed throughout the Orion crew module/launch abort system stack to test critical components of the spacecraft such as avionics, propulsion and crew life support. (Credit: Lockheed Martin)

### *NASA continues work on Orion*

On May 24, 2011, NASA announced that the Multi-Purpose Crew Vehicle (MPCV), also part of the NASA Authorization Act of 2010, will be based on the Orion Crew Exploration Vehicle design. The Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during space travel, and provide safe reentry.

NASA began a campaign of Orion landing tests at the Langley Research Center's Hydro-Impact Basin, splash testing the "boilerplate" test vehicle to investigate different kinds of water landing scenarios. The Orion also completed construction of its Ground Test Article (GTA) vehicle, the next higher-fidelity vehicle beyond the "boilerplate." The GTA was brought to the Orion Denver facility to begin the first campaign of vibro-acoustic testing to better understand the forces that will be transmitted to the inside of the Orion during a launch abort. NASA also flew a test of rendezvous and docking technology, known as STORRM, on the second to last flight of the Space Shuttle, STS-134, potentially supporting future docking operations.

## The human element

### *Defining capabilities and conducting research*

NASA defined and baselined the top-level requirements in the Human Exploration Capabilities Requirements Document and a draft program plan is in review. To this end, NASA continues to reduce the risk for human space exploration. The highest risks to human health and performance are investigated and mitigated by providing essential countermeasures and technologies for human space exploration. Risks include physiological effects from radiation, reduced and microgravity, and terrestrial environments, as well as unique challenges in medical support, human factors, and behavioral health support. NASA utilizes an Integrated Research Plan (IRP) to identify the approach and research activities planned to address these risks, whether on the ISS, or in a ground-based laboratory, on Earth. The Human Research Roadmap is the web-based tool for communicating the IRP content (see http://humanresearchroadmap.nasa.gov/).

NASA released two NASA Research Announcements in FY 2011. One released on January 27, Ground-Based Studies in Space Radiobiology, solicited research in space radiation biology to take place at the NASA Space Radiation Laboratory at Brookhaven National Laboratory, New York. Another released on August 23, the Joint NASA and National Space Biomedical Research Institute's Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions, solicited innovative research addressing risks identified in NASA's human research roadmap.

The Space Studies Board of the National Academies is conducting an evaluation of NASA's space radiation cancer risk model to identify any gaps in NASA's current research strategy. There are still uncertainties about estimating the health risks of exposure to galactic cosmic rays. As a result, NASA limits astronaut exposure to an amount that could make future long-duration space exploration difficult. On August 1, NASA provided the review committee a copy of the NASA report, "Space Radiation Cancer Risk Projections and Uncertainties—2010," which defines NASA's models for different conditions and individuals. With delivery of this report, NASA's active role in the evaluation was complete. The Space Studies Board committee has completed its evaluation and the final report should be available in early FY 2012.

## Outcome 1.3

Develop an integrated architecture and capabilities for safe crewed and cargo missions beyond low Earth orbit.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Complete design reviews for Space Launch System (SLS). | | | | | 1.3.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop top level Agency requirements and draft Program Plan for Space Launch System (SLS). | None | None | None | None | HEC-11-1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Complete design reviews for Multi-purpose Crew Vehicle (MPCV). | | | | | 1.3.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop top level Agency requirements and Program Plan for Multi-Purpose Crew Vehicle (MPCV). | None | None | None | None | HEC-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop technologies that enable biomedical research and mitigate space human health risks associated with human space exploration missions. | | | | | 1.3.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop and release two NASA Research Announcements that solicit from the external biomedical research community the highest quality proposals to mitigate space human health risks. | None | None | None | None | ERD-11-4 |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Perform research to ensure that future human crews are protected from the deleterious effects of space radiation. | | | | | 1.3.2.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the independent assessment of the updated NASA Space Radiation Cancer Risk Model used to project the cancer risk for current ISS crews and future exploration missions. | None | None | None | 10AC05 Green | ERD-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop exploration medical capabilities for long-duration space missions. | | | | | 1.3.2.3 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop and begin implementation of a research plan to address a recently discovered risk to crewmembers involving microgravity-induced visual alterations. | None | None | 9AC7 Yellow<br>9AC4 Green<br>9AC5 Yellow | 10AC06 Green<br>10AC07 Green<br>10AC07 Green | ERD-11-6 Green |

# Strategic Goal 2

# Expand scientific understanding of the Earth and the universe in which we live.

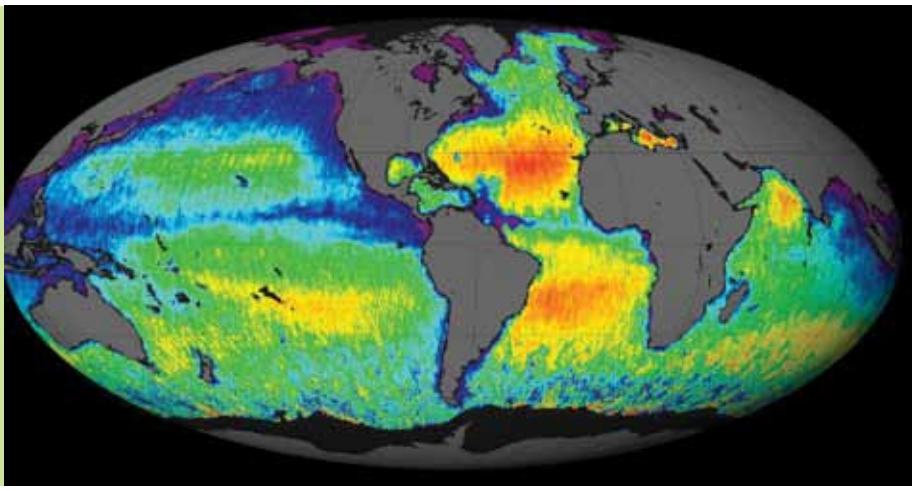
Since America's first exploratory steps in space with the launch of the Explorer I satellite in 1958, NASA has broadened its scientific reach with an increasingly sophisticated series of robotic missions that have visited asteroids, impacted comet nuclei, orbited the gas giants Jupiter and Saturn, imaged the Sun in stereo, observed planets around distant stars, and looked back in time to moments after the Big Bang. At the same time, NASA has studied Earth from space with increasing detail. The Agency has used its unique perspective from space in pursuit of answers to profound science questions: How and why are Earth's climate and environment changing? How do planets, stars, and galaxies originate? Is Earth the only source of life? How did the universe begin and what is its destiny?

NASA develops, operates, and mines data from science missions that will have a global impact on understanding humankind's place in the universe and the sustainability of Earth, guided by priorities set by the Nation's best scientific minds through the National Academies' decadal surveys for Earth Science, Heliophysics, Planetary Science, and Astrophysics. NASA's Science Mission Directorate (SMD) is responsible for serving these four themes through portfolios of space missions and mission-enabling programs, including suborbital missions, technology development, research and analysis, and data archival and distribution to sustain progress toward science goals.

## Benefits

SMD's programs lay the intellectual foundation for the robotic and human expeditions of the future while meeting today's needs for scientific information to address national concerns, such as climate change, the availability of natural resources, and space weather.

SMD has an essential role in NASA's education mission to inspire the next generation of explorers. The discoveries and new knowledge from missions and research programs consistently engage people's imaginations, inform teachers, and excite students about science and exploration. SMD is committed to using its resources to foster the broad involvement of the Earth and space science communities in education and public outreach with the goal of enhancing the Nation's formal education system and contributing to the broad public understanding of science, mathematics, engineering, and technology. NASA's science education program creates products using NASA's results in Earth Science, Heliophysics, Planetary Science, and Astrophysics research. The program sponsors educational activities at all levels of formal and informal education to provide opportunities for learners of all ages.



NASA's new Aquarius instrument aboard the Argentinian SAC-D spacecraft produced its first global map of the salinity, or saltiness, of Earth's ocean surface, providing an early glimpse of the mission's anticipated discoveries. The image, using data from August 25 to September 11, 2011, shows the water with the highest salinity in red and yellow (the subtropics in the Atlantic) and water with the lowest salinity in blue and purple (rainy belts along the equator, the northernmost Pacific, and around the Indian subcontinent and southeast Asia). Find out more about this image, including the grams of salt per kilogram of water attributed to each color. (Credit: NASA/GSFC/JPL-Caltech)

## Risks to Achieving Strategic Goal 2

**Cost and Availability of Expendable Launch Vehicles:** NASA continues to have concerns about the availability, reliability, and increased cost of expendable launch vehicle (ELV) options. Over the course of the last decade, the Delta II has been the workhorse for launching many robotic mid-sized spacecraft. Without this option, NASA has access only to costlier evolved ELVs (Delta IV, Atlas V), which were designed to launch payloads larger than required for many of the missions identified in the NASA Science Plan. Options in the small and medium classes are limited by the lack of reliable, NASA-certified launch vehicles. Possible cost growth in the evolved ELV class is an additional source of concern.

These problems will persist until more competitively priced new commercial launch vehicles become available and demonstrate reliability, potentially reducing the cost of launching missions and facilitating a return of commercial customers to U.S. launchers. In the wake of the launch vehicle failures on two NASA Earth Science missions, the Orbiting Carbon Observatory (OCO) in 2009 and Glory in 2011, the reliability of launch vehicles in this size range is keenly recognized as an aspect of this risk.

**International Partnerships:** NASA's science portfolio depends on solid, significant, and reliable international partnerships. These partnerships can help to defray costs and balance risks across the partners. In addition, these partnerships contribute significantly to a shared scientific understanding and ownership which greatly assists in advancing scientific understanding.

While international partnerships can help maintain higher effective mission flight rates in a reduced budget environment, they also introduce increased management complexities, as well as technical and programmatic risks. The proper balancing of these risks and rewards requires careful definition of partner interfaces and responsibilities.

**Availability of Plutonium-238:** The supply of Plutonium-238 (Pu-238) remains a limiting factor in the exploration of the solar system. NASA has already rescoped New Frontiers-3 due to the limited supply of the Pu-238. NASA requires Pu-238 to make power for missions that travel too far from the Sun for solar power generation. Russia has suspended implementation of its contract with the Department of Energy (DOE) for purchase of Russia's remaining supplies of Pu-238. NASA continues to explore its options with the DOE, and gained appropriation of funds for FY 2011 to begin analyzing the best approach to reestablish the supply.

# Outcome 2.1

## Advance Earth system science to meet the challenges of climate and environmental change.

NASA's Earth Science theme advances knowledge of the integrated Earth system, the global atmosphere, oceans (including sea ice), land surfaces, ecosystems, and interactions between all elements, including the impacts of humans. Earth Science uses a balanced portfolio of flight programs, research, technology development, and applied sciences to achieve its objectives—and serve national and international needs—in these areas.

The Earth Science Research Program advances understanding of the Earth system, its components and their interactions, its changes, and the consequences of these changes for life. The program pioneers the use of remote sensing data, primarily space-based, and sponsors basic disciplinary and interdisciplinary research, Earth system modeling efforts, the Airborne Science project (which provides access to aircraft and unmanned aircraft systems), and supercomputing efforts supporting a variety of programs, as well as education and outreach.

Earth Science completed several important mission milestones during the fiscal year. Many of these missions will serve more than one science objective.

- On June 7, 2011, NASA completed the Aquarius Launch Readiness Review (LRR), the last review of the spacecraft, its launch vehicle, and launch systems to ensure everything is ready. The mission launched on June 10 and began operations—"tasting" the saltiness of Earth's ocean surface—in September.
- Earth Science released the Earth Venture (EV)-2 Announcement of Opportunity on June 17, 2011, with the proposals received in September. Earth Venture is an element within Earth Science's Earth System Science Pathfinder Program, which conducts low-to-moderate cost, small-to-medium sized, competitively selected, principal investigator-led Earth science investigations.
- A review team completed the Mission Operations Review (MOR) for the Landsat Data Continuity Mission (LDCM) on October 28, 2010. They assessed the program's flight concept of operations, project management, operations and sustainment plans, safety and mission assurance, and other program aspects. The launch is planned for the first quarter of FY 2013.
- A review team completed the NPOESS Preparatory Project (NPP) Mission Readiness Review (MRR) on September 6, 2011. Like an LRR, the MRR determines if all systems are ready for a successful launch. MRR is distinguished from an LRR in that MRR also evaluates the readiness of the mission plan to accomplish the mission objectives. Earth Science kicked off FY 2012 with the successful launch of NPP on October 28.

### Understanding changes in the ozone layer, air quality, and aspects of atmospheric composition

#### *Using aircraft and satellites to study cirrus clouds*

In the past year, NASA researchers conducted an airborne field campaign to improve the characterization of mid-latitude cirrus clouds, the thin, wispy clouds blown by high winds into long streamers. The campaign, called Measurements from the Mid-latitude Airborne Cirrus Properties Experiment (MACPEX), was designed to fill a critical gap in scientists' knowledge about the microphysical properties of mid-latitude cirrus.

Information gained from MACPEX about the sizes, concentrations, and water contents in cirrus clouds is being used to improve basic understanding of cirrus formation and evolution, provide improved characterization of cloud properties for Earth system models, and enhance remote sensing retrieval algorithms (which transform satellite measurements into geophysical parameters—data products that can be used by researchers).

The researchers used NASA's WB-57 aircraft to fly over the continental U.S. and the Gulf of Mexico during March and April 2011. The WB-57 payload included an extensive array of instruments for measuring cirrus properties, aerosols, water vapor, tracers, and meteorological conditions. The MACPEX instrument suite employed recent advances in instrument design and analysis techniques that have mitigated chronic problems with previous instrumentation. To help validate the data, the MACPEX researchers coordinated many of the flights with observations from two satellites from the A-train

formation, the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) and CloudSat, and data from ground based instruments at the Department of Energy's Southern Great Plains site for validation. Earth Science will use the detailed measurements to better characterize cloud properties for incorporation into global climate models.

NASA's WB-57 taxis along the runway before going on a MACPEX flight. The wings carry instruments contained in "spearpods" and several other instruments bristle near the underside of the aircraft's nose. (Credit: NASA)

### *DISCOVERing better ways to monitor air pollutants*

The Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) mission is a four-year Earth Venture-funded campaign to improve the use of satellites to observe and conduct research on air quality in the lower atmosphere. A challenge for Earth-observing satellites measuring air quality is to distinguish between pollution high in the atmosphere and that near the surface where people live and breathe. DISCOVER-AQ will tackle this challenge through targeted, simultaneous airborne observations at high and low altitudes and ground-based observations. The campaign results will enable improvements in scientists' ability to monitor pollution from satellites, so that they can make better air quality forecasts, more accurately determine the sources of pollutants in the air and more closely determine the fluctuations in emissions levels.

The campaign employs NASA aircraft to make a series of flights with scientific instruments onboard to measure gaseous and particulate pollution. The series of flights—which will be made by NASA Langley Research Center's King Air and NASA's P-3B—commenced over the Baltimore-Washington, DC, area during summer 2011. Future flight campaigns may be conducted in Houston (2013) and Sacramento (2013), with a final site in 2014 to be determined.

The measurements were taken in concert with ground observations to shed light on how satellites could be used to make similar, consistent measurements over time, with the ultimate goal of putting better data in the hands of policymakers, elected officials, and scientists. Visit the DISCOVER-AQ site to find out more about the 2011 mission, how the data is being used, and some of the results to date.

### *Assessing the global impact of black carbon*

Black carbon exists as particles in the atmosphere and is a major component of soot. It has significant human health and climate impacts. At ground level, ozone is an air pollutant harmful to human health and ecosystems, and throughout the troposphere (the atmosphere's lowest layer) is also a significant greenhouse gas. In 2009, the United Nations Environment Programme (UNEP) was asked to organize an assessment to provide a scientifically credible basis for informed decision-making on black carbon issues. The reports from that assessment, as well as the 2010 report of the UNEP-led International Ozone Assessment, were both published this year.

UNEP provides leadership and encourages partnership in caring for the environment. NASA scientists and NASA-funded researchers participated and served in leadership roles in this activity. The assessment also used data from NASA satellites (Aura and past satellites and instruments like the Total Ozone Mapping Spectrometer (TOMS), the Stratospheric Aerosol and Gas Experiment (SAGE), and the Upper Atmosphere Research Satellite (UARS)), data from ground-based networks (the Advanced Global Atmospheric Gases Experiment (AGAGE) and the Network for the Detection of Atmospheric Composition Change (NDACC)), and atmospheric models.

The assessment team looked at the challenges created by black carbon in the atmosphere, like its contribution to the changing climate, melting snow and ice around the world, and reduced crop yields. Then they examined the potential effects of reduced emissions and recommended responses. The result was a comprehensive analysis of drivers of emissions, trends in concentrations, and impacts on climate, human health, and ecosystems of black carbon, as well as tropospheric ozone and its precursors. Black carbon, tropospheric ozone, and methane are often referred to as short-lived climate forcers, as they have a short lifetime in the atmosphere (days to about a decade) relative to carbon dioxide.

The assessment determined that under current policies, emissions of black carbon and ozone precursors are expected globally either to increase or to remain roughly constant unless further mitigation action is taken. It also cited scientific evidence and new analyses that demonstrate that control of black carbon particles and tropospheric ozone through rapid implementation of proven emission reduction measures would have immediate and multiple benefits for human well-being.

### *Stratospheric aerosol layer: impact of volcanic eruptions*

Researchers explored the variability of stratospheric aerosol loading between 1985 and 2010 with measurements from multiple spaceborne instruments, including SAGE II, CALIPSO, and sensors on European and Canadian platforms, GOMOS/ENVISAT and SIRIS/Odin. Following the 1991 eruption of Mount Pinatubo, stratospheric aerosol levels increased by as much as two orders of magnitude and only reached "background levels" between 1998 and 2002. From 2002 onwards, a systematic increase in stratospheric aerosols has been reported by a number of investigators.

Recently, studies done using ground-based lidar measurements have tentatively attributed this trend to an increase of sulfur dioxide entering the stratosphere associated with coal burning in Southeast Asia. However, these satellite measurements demonstrate that the observed trend is mainly driven by a series of moderate but increasingly intense volcanic eruptions primarily at tropical latitudes. These events injected sulfur directly to altitudes between 11 and more than 12 miles (18 and 20 kilometers). The resulting aerosol particles are slowly lofted into the middle stratosphere and are eventually transported to higher latitudes.

A study published in July 2011 shows that none of the climate models have included the effect of the slow increase in stratospheric aerosols during the past decade. Researchers also have used these measurements to assess the role of aerosols in radiative forcing (the change in the balance between the incoming and outgoing radiation energy between the troposphere and stratosphere) and their impact to climate model calculations of global change. If these measured increasing trends were not taken into account, climate model projects would overestimate radiative forcing and global warming in coming decades.

### *Seasonal variation of black carbon transport from Asia to the Arctic*

Researchers conducted extensive measurements of black carbon aerosol in and near the North American Arctic during the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) aircraft campaign in April and June–July 2008, and important new results were published by NASA-funded researchers in 2011. Analyses of observations from the ARCTAS aircraft mission provided new perspectives on the transport of pollution to the Arctic and its climate implications. They showed that the Arctic is subject to a complex combination of influences from Asian, European, and North American anthropogenic (human-made) pollution, as well as Russian fires, known as biomass burning.

NASA's P-3, one of the aircraft used for the ARCTAS campaign, is ready to be moved into the airfield hangar after its arrival at Thule Air Base, Greenland on April 8, 2008. (Credit: NASA)

The researchers found that both fossil fuel and biomass burning are major contributors of black carbon in the Arctic. Further, the results show that the impact of black carbon emitted from anthropogenic sources in East Asia on the Arctic was very limited in both spring and summer. The biomass burning emissions in Russia in spring were found to be the most important sources of black carbon transported to the North American Arctic.

ARCTAS also revealed that the prominent satellite observations of Bromine Monoxide hotspots in polar spring are not due to boundary layer bromine, as previously thought, but to tropopause depressions (the point between the troposphere and the stratosphere where air stops cooling with height and becomes almost completely dry) combined with higher-than-expected inorganic bromine in the lower stratosphere. Bromine has been linked to ozone destruction, so elevated bromine has important consequences for ozone in the Arctic stratosphere and troposphere.

### *Radiative effects of biomass burning aerosols*

Direct and semidirect radiative effects of biomass burning aerosols from southern African fires during July through October were investigated using 20-year runs of the Community Atmospheric Model (CAM) coupled to a slab ocean model. Aerosol optical depth is constrained using observations in clear skies from MODIS and for aerosol layers above clouds

from CALIPSO. Over the ocean, where the aerosol layers are primarily located above cloud, negative top of atmosphere semidirect radiative effects associated with increased low cloud cover dominate over a weaker positive all-sky direct radiative effect. In contrast, over the land where the aerosols are often below or within cloud layers, reductions in cloud liquid water path lead to a positive semidirect radiative effect that dominates over a near-zero direct radiative effect. Over the ocean, the cloud response can be understood as a response to increased lower tropospheric stability, which is caused both by radiative heating in overlying layers and surface cooling in response to direct aerosol forcing. Over land, decreased liquid water path is consistent with weaker convection driven by increased static stability. Over the entire region, the overall top of atmosphere radiative effect from the biomass burning aerosols is almost zero due to opposing effects over the land and ocean. However, the surface forcing is strongly negative, which leads to a reduction in precipitation and also a reduction in sensible heat flux. The results highlight the importance of semidirect radiative effects and precipitation responses for determining the climatic effects of aerosols in the African region.

## Using NASA capabilities to improve extreme weather monitoring and prediction

### *Getting a GRIP on tropical storms and hurricanes*

In August-September 2010, NASA conducted the Genesis and Rapid Intensification Processes (GRIP) field experiment to better understand the physical processes that control hurricane formation and intensity change.

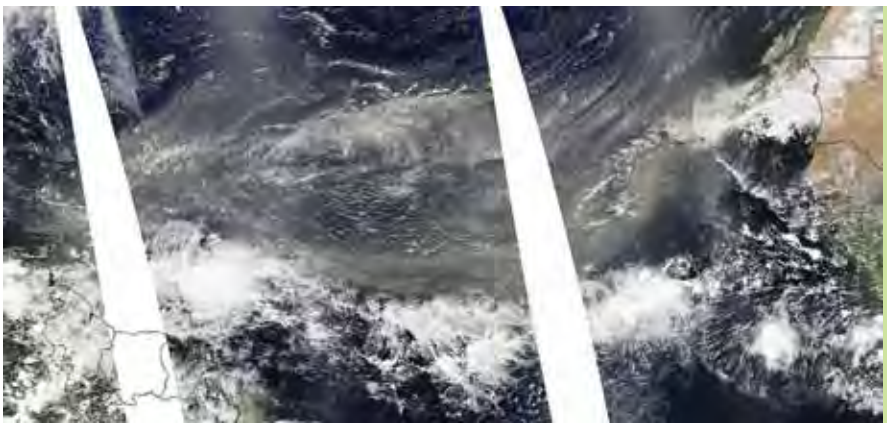
NASA and National Science Foundation aircraft teamed up to perform coordinated flights for the genesis of Hurricane Karl and Tropical Storm Matthew and the non-development of the remnants of Tropical Storm Gaston. NASA's space and airborne observational capabilities put it in a unique position to assist the hurricane research community in addressing shortcomings in the current state of the science. The relatively recent launch of several new satellites, the prospect of using high-altitude unmanned aircraft systems for hurricane surveillance, and the emergence of new remote sensing technologies offer new research tools that need to be explored and validated. New remote sensing instruments for wind and temperature may lead to improved characterization of storm structure and environment. In June 2011, the GRIP project hosted a science meeting to share some of the results. The presentations are available at http://grip.nsstc.nasa.gov/science_meeting.html.

### *SPoRT transitions important data to Weather Forecasting Offices*

The Short-term Prediction Research and Transition (SPoRT) Center is a NASA project to transition unique observations and research capabilities to the operational weather community to improve short-term forecasts on a regional scale. In fall 2010, the National Weather Service's Office of Science and Technology asked SPoRT to transition experimental ocean surface wind vectors derived from WindSat to selected forecast offices around the country. Developed by the Naval Research Laboratory, WindSat measures ocean surface, wind speed, and wind direction from space. The data is currently undergoing evaluation by forecasters in the Alaska region and the Monterey Weather Forecasting Office.

### *Demonstrating the connection between the Saharan Air Layer and hurricanes*

A study using data from a suite of instruments aboard Aqua—the Atmospheric Infrared Sounder (AIRS) and Advanced Microwave Sounding Unit (AMSU)—demonstrated that information about intensely dry, warm air associated with the Saharan Air Layer improves hurricane simulations. It also demonstrated that the Saharan Air Layer, which often sits over the cooler, more humid surface air of the Atlantic Ocean, contributes to hurricane formation but suppresses hurricane intensification.



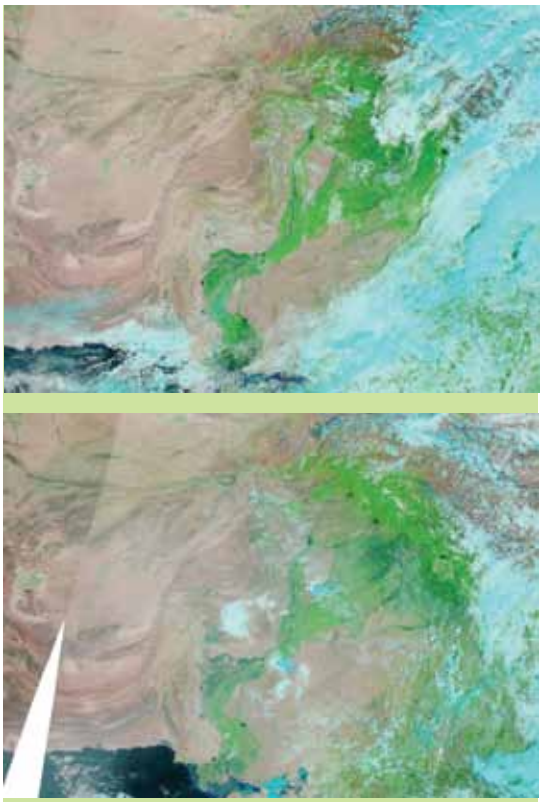
A well-defined plume of dust swept across the entire Atlantic Ocean on June 24, 2009. In this photo-like image taken by the MODIS instrument on Aqua in three consecutive overpasses, the dust stretches from its origins in Africa's Sahara Desert to the Lesser Antilles Islands on the eastern edge of the Caribbean Sea. Read more about this image. (Credit: NASA/J. Schmaltz, MODIS Rapid Response)

### *Better forecasting of precipitation with AIRS*

The impact of assimilating quality-controlled AIRS temperature retrievals obtained from partially cloudy regions was assessed in a recent NASA study, with focus on precipitation produced by the Goddard Earth Observing System Model (GEOS)-5 data assimilation and forecasting system for three tropical cyclones. Scientists found that the precipitation analysis obtained when assimilating AIRS cloudy retrievals can capture regions of heavy precipitation associated with tropical cyclones much better than without AIRS data or when using AIRS clear-sky radiances. The corresponding precipitation forecasts initialized from AIRS analysis showed better performance than forecasts initialized from previous analyses up to two-day forecasting.

### *Satellite data connect two super-extreme weather events of 2010*

NASA satellite and re-analyses data show that the two super-extreme weather events in the summer of 2010—the Russian heat wave and the Pakistan flood—were physically connected. The development of an atmospheric blocking high associated with Russian heat wave set off a large-scale atmospheric Rossby wave, which was instrumental in triggering torrential rain over northern Pakistan.



Monsoon floods struck Pakistan's southern Sindh Province in August 2011. A drain breach in Badin District left residents marooned on dry spots separated by high water. Terra's MODIS instrument captured these images on August 16, 2011 (top), and July 17, 2011 (bottom). The images show southern Pakistan, near the coast and near the border with India. Both images use a combination of visible and infrared light to increase contrast between water and land. Water ranges in color from electric blue to navy. Vegetation is green, and bare ground is pink-beige. Clouds are pale blue-green. (Credit: NASA/MODIS Rapid Response Team)

The recent study by NASA scientists found that an abnormal Rossby wave sparked extreme heat and persistent wildfires in Russia as well as unusual downstream wind patterns that shifted rainfall in the Indian monsoon region and fueled heavy flooding in Pakistan. Atmospheric Rossby waves are giant flows of high-altitude winds that are formed by the shape and rotation of Earth. Always moving from east to west, they have major effects on large-scale ocean circulation, weather, and climate, and they form the jet streams. The Russian heat wave started before the floods, but both events attained maximum strength at approximately the same time, the researchers found by analyzing NASA satellite data measuring land surface temperature, precipitation intensity, and wildfire activity. Under normal summertime conditions, the jet stream pushes weather fronts through Eurasia in four or five days, but in July 2010 a large-scale, stagnant weather pattern—known as an Omega blocking event—developed over a high-pressure ridge above western Russia. This blocking event, which divided the jet stream, had the effect of slowing the Rossby wave and prevented the normal progression of weather systems from west to east. As a result, a large region of high pressure formed over Russia and trapped a hot, dry air mass that stopped precipitation and dried out the vegetation.

Meanwhile, the blocking pattern created unusual downstream wind patterns over Pakistan. Areas of low pressure on the leading edge of the Rossby wave formed in response to the high that pulled cold, dry Siberian air into lower latitudes. This high brought upper level air disturbances farther south than is typical, which helped shift the entire monsoon rainfall system north and west, bringing heavy monsoon rains squarely over the northern part of Pakistan.

While the new study highlights the degree of interconnection that can exist between two seemingly unrelated weather events, many questions remain. For example, why did such a powerful blocking high form in the first place? And did some particular process occurring on the land or in the atmosphere sustain and strengthen it? Furthermore, graphite-like dark particles in wildfire smoke (a type of aerosol called black carbon) may have helped burn clouds away, making the surface even drier and more fire prone.

## Understanding land cover, biodiversity, and a changing ecosystem

### *Publishing research results for the North American Carbon Program*

In the past year, NASA research has advanced in quantifying the state of global land cover, analyzing interannual variability and trends in terrestrial and marine ecosystems, and explaining the processes that control productivity and carbon cycling, one of the most important cycles of Earth, allowing for carbon to be recycled and reused throughout the biosphere and all of its organisms. The researchers have published many peer reviewed journal articles on the results of the interagency North American Carbon Program's (NACP's) interim synthesis studies.

Researchers have characterized and, in several cases, quantified the effects of differing types of disturbances, caused by natural phenomena as well as by human actions, on carbon sources and sinks at continental scales. Researchers will use this new understanding, along with the findings of an on-going model intercomparison study for NACP, to improve carbon cycling models.

### *National Biomass and Carbon Data Set released in April 2011*

Hectare-scale maps of canopy height, aboveground biomass, and associated carbon stock for the forests and woodlands of the contiguous United States were released to the public. The National Biomass and Carbon Dataset (NBCD) project produced maps of these key forest attributes at an unprecedented spatial resolution of 97.5 feet (30 meters). The project was initiated in 2005 with support from NASA, the U.S. Geological Survey, and the U.S. Department of Agriculture's Forest Service. NASA space-borne imagery (Shuttle Radar Topography Mission and Landsat-7), land use/land cover information, topographic survey data, and extensive forest inventory data were combined. Across 66 individual mapping zones, spatial data, field observations, and statistical models were used to generate the canopy height, above ground biomass, and carbon stock maps, which were then merged to form national-scale products.

The data set is available at http://www.whrc.org/mapping/nbcd/nbcd_reg.html.

### *Analyzing phytoplankton's role in the carbon cycle*

In 2010, researchers published the first satellite-based analysis of major phytoplankton classes (micro-, nano-, and picophytoplankton) in the world's oceans, and their contribution to primary production. Primary production is a measure of the amount of biomass produced through photosynthesis by plants. The analysis of interannual variations revealed large anomalies in class-specific primary production as compared to the 10-year mean cycle in both the productive North Atlantic basin and the more stable equatorial Pacific upwelling. Assessing climatology and interannual changes in primary production associated with three major phytoplankton classes within the global ocean represents a significant contribution to our ability to understand and quantify carbon cycling in the upper ocean.

Phytoplankton are microscopic organisms that live in both salty and fresh water. Like land plants, phytoplankton have chlorophyll to capture sunlight, and they use photosynthesis to turn it into chemical energy. They also consume carbon dioxide and release oxygen. Previous research has focused on phytoplankton as a single group. The researchers note that the different function, structure, and size of phytoplankton communities influence many biogeochemical processes important to primary production. The researchers applied algorithms that allowed them to determine distinct groups of phytoplankton from ocean color remote sensing data gathered by NASA's Sea-viewing Wide Field-of-view Sensor (SeaWiFS). The algorithms cannot directly quantify the production of each phytoplankton group; that information was interpreted by the researchers.

The researchers found that microphytoplankton appear as a major contributor to total primary production in coastal upwelling systems (70 percent) and temperate and subpolar regions (50 percent) during the spring–summer season. Picophytoplankton make their biggest contribution (45 percent) in subtropical oligotrophic (having low accumulation of dissolved nutrient salt, sparse algae and other organisms, but high oxygen content) gyres. Nanophytoplankton provide a ubiquitous, substantial contribution (30 to 60 percent). There appears to be very little interannual variability in the annual cycle of primary production for total phytoplankton over the global ocean. However, when the researchers looked at the different phytoplankton classes, they saw different degrees of variability. In contrast to the observations made on the global scale, the regional scale analysis reveals large year-to-year variations in total and class-specific primary production.

### *Publishing findings on carbon cycle and biodiversity*

A number of NASA-supported projects have used remotely sensed data and ecological models to define the habitats of organisms and how they change, or are likely to change, in response to physical, chemical, and biological variations in their surroundings. These projects are not only important for understanding how organisms respond to land cover change and other changes in their environment, but they have large implications for managing natural systems to promote the conservation of biodiversity.

In 2011, an additional special issue section of the *Journal of Geophysical Research* reported on results of the Southern Ocean Gas Exchange Experiment (SO GasEx), which studied the transfer of gases like carbon dioxide from ocean to atmosphere. Funded by NASA, the National Science Foundation, and NOAA, the multidisciplinary field process study aimed to better understand how air–sea gas exchange affects and is affected by Southern Ocean biogeochemistry. The journal also published a special collection of papers on the study of vegetation three-dimensional structure, which includes canopy height and density, from space. Because of the inherent difficulty of measuring forested vegetation three-dimensional structure on the ground, this important component of biodiversity and habitat has mostly been restricted to local measurements or, for larger scales, generalizations. Spaceborne lidar and remote sensing instruments have made it possible to derive accurate three-dimensional measurements and create models of biomass structure and changes.

## Quantifying water reservoirs and assessing global water cycle changes and water quality

### *Multiple satellite data sources, improved models and field campaigns*

Over the past year, NASA has continued its progress improving its description of the water cycle, including the size and movement between its stores. Coincident use of multiple satellite data sources (e.g., Advanced Microwave Scanning Radiometer for EOS (AMSR-E), Tropical Rainfall Measuring Mission (TRMM), and Moderate Resolution Imaging Spectroradiometer (MODIS)), especially those of different but linked variables have led to improvement both in the quantification of the water cycle and the uncertainty estimates of its components, with both groundwater and total storage two new variables being provided. Furthermore, Gravity Recovery and Climate Experiment (GRACE) data has been used to provide large area estimates of the change in total water storage of the land that by definition has to equal the sum of precipitation, evaporation, and run-off. Refinement has been made globally, regionally, and on annual and monthly time scales.

Following the study published in 2009 that used GRACE data to identify current rates of groundwater depletion in India, a recent study showed that California's major water source (the Sierra Nevada mountains) and America's fruit basket (California's Central Valley) were also experiencing significant rates of groundwater depletion. During the 2003-2010 time period studied, the combined Sacramento-San Joaquin River Basins lost the equivalent volume of Lake Mead in freshwater, nearly two-thirds of which came from groundwater. The work has resonated across the country, renewing calls for enhanced groundwater management, and garnering support for an accelerated GRACE follow-on mission.

Annually the Bulletin of the American Meteorological Society releases a "state of the climate" issue. For the first time NASA is able to contribute two new variables to this report. GRACE data combined with large-scale hydrological modeling are able to contribute important information about the "climate" of Groundwater and Total Water Storage. Not only is this affirmation that these variables are important but also highlights that satellite remote sensing is a requirement for this climate variable.

### *Studies leverage multiple field campaigns for vital downscaling approaches*

A NASA supported study has allowed for the exploitation of data from numerous field studies (e.g., Southern Great Plains and Soil Moisture Experiment) that have been funded in full or in part by NASA over the last two decades. Though different field campaigns emphasized different scientific objectives, this study was able to coalesce the information content of them all to understand aspects of soil moisture variability. The study used this to better understand the information captured by remote sensing at different spatial resolutions, especially revealing controlling aspects on the variability (i.e., ecological, topographical, and others). This has resulted in important guidance on methods of creating and using in situ gauges to evaluate remote sensing products. It also has led to ways to downscale soil moisture, either observations or models. This is particularly important in making scientific research data more readily usable by agriculture and water resource managers.

## Gaining a better understanding of the roles of the ocean, atmosphere, land, and ice in the climate system

NASA continues to provide specialized support for research to better understand the interactions of the oceans, atmosphere, and ice in the Earth climate system. Recent efforts have focused on the integration of data acquired from satellites, aircraft, and ground networks into climate modeling at global and regional scales. Over the past year, these observations continue to show higher than climatologically normal surface temperatures, indicative of a warming climate.

### *Monitoring global sea level and sea surface temperature trends and climate variability*

For the past 18 years, the U.S.–French Jason-1, Jason-2, and Topex/Poseidon satellite missions have provided a long-term time series of globally averaged mean sea level, revealing the overall trend to be increasing at 0.14 inches (3.4 millimeters) per year. In addition, its interannual variability was closely correlated with the El Niño–Southern Oscillation phenomenon, which serves as a reminder that short-term variations (five years or less) do not necessarily signify changes in global warming. Rather, they can be attributed to changes in oceanic heat content, or more likely, to shifting patterns of precipitation over land and ocean.

Satellite sea surface temperature data for the past three decades reveal a record anomaly within a large mid-latitude region of the south-central Pacific during the mature phase of the 2009–2010 El Niño. The warming in this region was confined to the upper 162.5 feet (50 meters) of the ocean, and has been attributed to wind changes associated with an extreme and persistent anticyclone, with surface heat flux and ocean processes playing equally important roles. This anticyclone also diverted circumpolar westerlies and warm air toward Antarctica, producing three-decade high sea surface temperatures in the Bellingshausen Sea.

The global mean surface temperature was at a record level in 2010, despite a relatively cool equatorial Pacific region and unusually cool conditions over the eastern United States and Eurasia near the end of 2010. The year ended in a statistical tie with 2005 as the warmest year in the Goddard Institute for Space Studies (GISS) temperature record.

In late 2009 to early 2010, the Gravity Recovery and Climate Experiment (GRACE) pair of satellites observed a record increase in ocean bottom pressure over a large mid-latitude region of the southeast Pacific Ocean. This observation suggests that a similar, simultaneous signature in sea surface height, captured by satellite altimeters, was mainly due to mass convergence. Using scatterometer data and atmospheric reanalysis products, along with the GRACE and altimeter data, researchers determined that the joint signal was associated with a strong and persistent anticyclone in late 2009. This driving wind pattern was related to an unusual central Pacific El Niño event, one that is becoming more prevalent than the better-known eastern Pacific El Niño.

### *Shrinking ice leads to further surface warming*

Satellite data during the past year continued to show a decline in Arctic sea ice cover, both in extent and thickness. The minimum extent for September 2011, if reached, would surpass the record minimum established in 2007. Data has shown that thinning and receding Arctic sea ice increases the net ocean-atmosphere heat output and now is playing a role in increasing surface air temperatures in the Arctic. Vanishing sea ice has also been associated with an increase in cloudiness, which reduces the emission of long wave radiation from the Arctic, further increasing temperatures in the region.

Various studies of the Greenland ice sheet highlight the profound ice loss that has occurred there since the 1990s, much of it through fast-flowing outlet glaciers. Furthermore, models suggest that Pine Island Glacier, in west Antarctica, is at risk of losing its ice shelf, which could lead to a dramatic increase in ice flow there. These changes, in all aspects of the cryosphere (the areas of Earth where water is in solid form such as sea ice, lake ice, snow, and glaciers), emphasize the need for continued monitoring and improved modeling.

### *Getting better data and advanced computing to the research community*

Over the past year, NASA's investments in both capacity and new capabilities in data processing have enabled scientists to transform the output from remote sensing and in-situ instruments into the scientific measurements needed to improve both understanding and predictive capability of the oceans, atmosphere and ice. These tools have accelerated the process of scientific discovery by permitting the research community to assimilate the large quantities of data obtained and have ensured the stewardship of that data over the long periods of time needed to understand the climate system's behavior. Similarly, predictive and diagnostic modeling continues to make significant contributions to the understanding of the Earth system. Facilitated by increases in supercomputing capabilities, NASA models were pushed to higher

resolutions. Higher resolution simulations show improved fidelity to observations. Significant improvements have been made in coupling regional and global climate models, developing tools that will improve understanding of regional climate change.

## Understanding the dynamics of Earth's surface and interior to enhance resilience and mitigation to natural hazards

### *NASA begins building new, high-accuracy receivers*

Following earlier investments, NASA initiated the development of a new Global Navigation Satellite System (GNSS) spaceborne receiver, the Tri-GNSS (Tri-G) during 2010. This receiver will replace the very successful BlackJack Global Positioning System (GPS) receiver. The prototype receiver will be available in 2013. GNSS receivers detect, decode, and process signals from the GNSS satellites (currently GPS and Global Navigation Satellite System (GLONASS) and, in the future, Galileo). High-accuracy measurements of the change in receiver locations over time allow researchers to study the motions of tectonic plates, displacements associated with earthquakes, and Earth orientation. The receiver also will provide the needed positioning and timing capability required for the missions recommended by the National Academies' Earth science decadal survey. NASA's Crustal Dynamics Data Information System (CDDIS) supports data archiving and distribution activities for the space geodesy and geodynamics community, including GNSS data.

### *GRACE again detects crustal dilatation at a large subduction zone earthquake*

Scientists have noted small but detectable changes in the Gravity Recovery and Climate Experiment (GRACE) satellites' relative trajectory after the M8.8 Maule, Chile, earthquake on February 27, 2010, that can be used to delineate the shift in the gravity field. A gravity anomaly of –5 mGal with a spatial scale of 308 miles (500 kilometers) was found east of the epicenter after the earthquake. Based on coseismic models, the long wavelength negative gravity change is primarily the result of crustal dilatation as well as surface subsidence in the onland region. The offshore positive gravity anomaly predicted from finite fault coseismic models is considerably smaller because the gravity changes due to surface uplift and interior deformation are opposite in polarity. Research suggests a role for large-scale gravity observations in deciphering changes of Earth's interior during great earthquakes by filling in the seldom-observed long wavelength spectrum of earthquake deformations as a complement to surface geodetic measurements and seismic data.

### *Providing natural hazard data quickly to help emergency response*

The Advanced Rapid Imaging and Analysis (ARIA) Center is an emergency response project under development at the Jet Propulsion Laboratory and the California Institute of Technology. The ARIA Center plans to provide the infrastructure to generate imaging products, using NASA resources, in near real-time to aid the Nation in responding to natural disasters like earthquakes, volcanic activity, and landslides.

An initial effort, through a subproject called ARIA-EQ, has focused on responding to significant earthquakes and will provide a prototype near real-time global large earthquakes analysis system using a combination of seismological, geodetic, and tsunami observations. The March 11, 2011, Tohoku earthquake in Japan demonstrated the true potential of this team to generate rapid, accurate information based on seismic and geodetic information. The U.S. Geological Survey and other organizations used ARIA-EQ products to provide situational awareness for the event, as well as to identify neighboring zones of concern with respect to similar future earthquakes. ARIA data, along with other Earth observation data, of this event is available at the Tohoku Event Supersite.

## Using NASA information in decision-making activities for societal benefits.

### *Starting new projects*

In FY 2011, the Applied Sciences Program awarded 35 new decision-support applications projects from an interagency solicitation focused on using Earth observations to help managers assess land-use vulnerability and craft practical strategies for land management in a changing climate (see the Research Opportunities in Space and Earth Sciences (ROSES)–2010 solicitation).

The Applied Sciences Program initiated a new Air Quality Applied Sciences Team (AQAST) to assist state and Federal air quality agencies in using the latest scientific knowledge and remote sensing techniques. AQAST has the Earth science resources, from satellites and suborbital platforms, to carry out quick-turnaround research responding to urgent and evolving needs of air quality management.

### *A fiscal year of using NASA products for public benefit*

USAID Administrator Rajiv Shah, left, and NASA Administrator Charles Bolden shake hands after signing a five-year Memorandum of Understanding on April 25, 2011. The agreement formalizes ongoing agency collaborations that use Earth science data to address developmental challenges and to assist in disaster mitigation and humanitarian responses. The agreement also encourages NASA and USAID to apply geospatial technologies to solve development challenges affecting the United States and developing countries. (Credit: NASA/P.E. Alers)

NASA teamed with the U.S. Drought Monitor to incorporate drought indicators for soil moisture and groundwater based on data from the GRACE satellite. Drought Monitor is a synthesis of multiple indices and impacts that represents a consensus of Federal and academic scientists. The Drought Monitor product is evolving and being refined over time to better reflect decision-makers needs and to incorporate new data products. At an April 2011 Water Resources Workshop, the team delivered the first drought indicator products, meeting a major milestone in the project.

In October 2010, the joint NASA–U.S. Agency for International Development (USAID) SERVIR Program launched a new, third hub to support the developing countries of the Hindu Kush–Himalayan region in environmental management, disaster response, and public health. Approximately 1.3 billion people depend on the ecosystem services provided by the Himalayan mountains, yet the region is known as Earth's "third pole" because of its inaccessibility and the vast amount of water stored there in the form of ice and snow. SERVIR is integrating Earth science data from NASA satellites with geospatial information products from other government agencies to support and expand SERVIR–Himalaya's host institution's focus on critical regional issues such as disaster management, biodiversity conservation, trans-boundary air pollution, snow and glacier monitoring, mountain ecosystem management, and climate change adaptation. During the Pakistan floods of late 2010, this new hub provided vital data products, helping aid agencies direct patients to alternate health care facilities not threatened by the floods. (Read more about the new SERVIR hub.)

SERVIR, which gets its name from the Spanish word meaning "to serve," also has a hub located at the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) in Panama and the Regional Center for Mapping of Resources for Development (RCMRD) in Kenya. During FY 2011, SERVIR–Mesoamerica aided the preparation and response to Tropical Storm Emily, which was the 50th extreme event it had aided in Latin America and the Caribbean since 2004. SERVIR–Mesoamerica also has developed a pilot project for the Geospatial Information System for Fire Management (SIGMA-I) in Guatemala to generate products that highlight the importance of systematic and informed planning for prevention and control of wildfires, which have been damaging wild areas and savannas. SERVIR–East Africa worked with 14 land managers from Kenya, Tanzania, Uganda, Rwanda, and Ethiopia to create wall-to-wall land cover maps for their respective countries. The SERVIR–Africa and the Kenya Meteorological Department are teaming to give decision-makers flood forecasts with longer lead-times (read more on this story).

The DEVELOP Program, an internship program for young professionals to develop Earth science applications, set new records this fiscal year. DEVELOP received 716 student nominations, accepted 239 students (33 percent of those nominated), and conducted 49 projects. The program amplified its outreach efforts by creating virtual project poster sessions—people online anywhere could experience the students' project results and improve their own understanding of NASA Earth science capabilities. In FY 2012, DEVELOP plans to establish new nodes in Missouri and Colorado, expanding the number of applications focused on the Midwest and Mountain West.

In spring 2011, the Applied Sciences Program's Gulf of Mexico Initiative mapped the floodwaters of the lower Mississippi River. This included mapping the extent of flooding of Louisiana's Atchafalaya River Basin due to the opening of the Morganza spillway and tracking the plume of floodwaters from the Bonne Carré spillway through Lake Pontchartrain and into the Gulf of Mexico. The Gulf of Mexico is a vital economic engine—

A National Space Science and Technology Center (NSSTC) senior research scientist from the University of Alabama in Huntsville trains three researchers from El Salvador to use SERVIR. (Credit: SERVIR)

providing over a billion pounds of fresh seafood every year, thriving shipping ports, and crude oil production—and thriving but sensitive ecological region in the United States. It is vulnerable to both natural and human-made impacts. The program created the Gulf of Mexico Initiative to address coastal management issues using Earth Science's products.

### *Planning for the future*

The Applied Sciences Program pursued efforts to engage the applications community in early stage planning for upcoming satellite missions. The program held an event for end users from the private sector and government focused on environmental conservation to discuss future data needs for applications and to examine potential applications of eight upcoming NASA Earth observing satellites. Key issues for the users were improving higher-level data products, increasing the ease of integration into decision support systems, data accuracy, and visualizations.

| **Outcome 2.1** | | | | | |
|---|---|---|---|---|---|
| Advance Earth system science to meet the challenges of climate and environment change. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | **2.1.1.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding and improving predictive capability for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | **7ESS1 Green** | **8ES01 Green** | **9ES1 Green** | **10ES01 Green** | **ES-11-1 Green** |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch at least two missions in support of this objective. | | | | | **2.1.1.2 Green** |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Aquarius Launch Readiness Review. | **None** | **8ES10 Yellow** | **9ES4 Green** | **10ES02 Yellow** | **ES-11-2 Green** |
| Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing. | **7ESS6 Yellow** | **8ES04 Yellow** | **9ES2 Green** | **10ES22 Green** | **ES-11-3 Yellow** |
| ***Why NASA rated APG ES-11-3 Yellow:*** The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.) | | | | | |
| Release Earth Venture 2 (EV-2) Announcement of Opportunity. | **None** | **None** | **None** | **None** | **ES-11-4 Green** |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | **2.1.2.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in enabling improved predictive capability for weather and extreme weather events. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | **7ESS2 Green** | **8ES02 Green** | **9ES7 Green** | **10ES04 Green** | **ES-11-5 Green** |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch at least two missions in support of this objective. | | | | | **2.1.2.2 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Global Precipitation Mission (GPM) Systems Integration Review. | **None** | **8ES06 Yellow** | **9ES8 Yellow** | **10ES06 Green** | **ES-11-6 Yellow** |
| ***Why NASA rated APG ES-11-6 Yellow:*** Both the NASA spacecraft and instrument developments are experiencing challenges in subsystem deliveries. These development challenges are resulting from various issues including defects discovered in flight parts, component manufacturing throughput issues and workmanship issues at supply vendors. In addition, the delivery of the JAXA (Japanese space agency)-provided Dual Precipitation Radar (DPR) instrument has been delayed due to disruptions at, and damage to, the test facility resulting from the March 2011 earthquake. Technical issues with the DPR were also identified during environmental testing. It is currently estimated that these challenges will result in a launch readiness delay of eleven months, from July 2013 to June 2014. (See page 178 for the Performance Improvement Plan.) | | | | | |

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.1.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in quantifying, understanding and predicting changes in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7ESS3 Green | 8ES03 Green | 9ES10 Green | 10ES07 Green | ES-11-7 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch at least two missions in support of this objective. | | | | | 2.1.3.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Landsat Data Continuity Mission (LDCM) Mission Operations Review. | None | None | 9ES11 Green | 10ES08 Green | ES-11-8 Green |
| Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing. | 7ESS6 Yellow | 8ES04 Yellow | 9ES2 Green | 10ES22 Green | ES-11-3 Yellow |
| ***Why NASA rated APG ES-11-3 Yellow:*** The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.1.4.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in quantifying the key reservoirs and fluxes in the global water cycle and assessing water cycle change and water quality. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7ESS5 Green | 8ES05 Green | 9ES13 Green | 10ES09 Green | ES-11-9 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch at least two missions in support of this objective. | | | | | 2.1.4.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Soil Moisture Active-Passive (SMAP) Confirmation Review. | None | None | 9ES14 Green | 10ES10 Yellow | ES-11-10 Yellow |
| ***Why NASA rated APG ES-11-10:*** The SMAP Confirmation Review was delayed to FY 2012 because of difficulties in identifying an acceptable launch vehicle for the mission. NASA's Earth Science program has been impacted by the current limited availability of launch vehicles in the medium size range that is appropriate for most of its missions. (See page 178 for the Performance Improvement Plan.) | | | | | |
| Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing. | 7ESS6 Yellow | 8ES04 Yellow | 9ES2 Green | 10ES22 Green | ES-11-3 Yellow |
| ***Why NASA rated APG ES-11-3 Yellow:*** The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.) | | | | | |
| Complete the Global Precipitation Mission (GPM) Systems Integration Review. | None | 8ES06 Yellow | 9ES8 Yellow | 10ES06 Green | ES-11-6 Yellow |
| ***Why NASA rated APG ES-11-6 Yellow:*** Both the NASA spacecraft and instrument developments are experiencing challenges in subsystem deliveries. These development challenges are resulting from various issues including defects discovered in flight parts, component manufacturing throughput issues and workmanship issues at supply vendors. In addition, the delivery of the JAXA (Japanese space agency)-provided Dual Precipitation Radar (DPR) instrument has been delayed due to disruptions at, and damage to, the test facility resulting from the March 2011 earthquake. Technical issues with the DPR were also identified during environmental testing. It is currently estimated that these challenges will result in a launch readiness delay of eleven months, from July 2013 to June 2014. (See page 178 for the Performance Improvement Plan.) | | | | | |

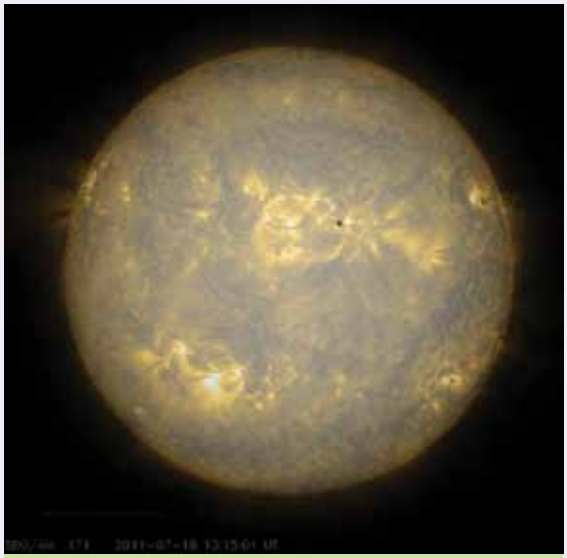
| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.1.5.1 Green |
| **FY 2011 Annual Performance Goal** | **FY 07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding the roles of ocean, atmosphere, land, and ice in the climate system and improving predictive capability for future evolution. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7ESS7 Green | 8ES07 Green | 9ES15 Green | 10ES11 Green | ES-11-11 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| HPPG: In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011. | | | | | 2.1.5.2 Red |
| ***Why NASA rated Performance Goal 2.1.5.2 Red:*** This high priority performance goal was not met, due to the loss of the Glory mission when the fairing from the Taurus XL launch vehicle failed to separate from the rocket. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission was successfully launched on October 28, 2011. (See page 164 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) Mission Readiness Review. | None | None | None | None | ES-11-12 Green |
| Complete the Glory Launch Readiness Review. | 7ES8 Yellow | 8ES09 Yellow | 9ES3 Red | 10ES21 Yellow | ES-11-13 Red |
| ***Why NASA Rated APG ES-11-13 Red:*** The Glory Launch Readiness Review was completed on February 21, 2011, with a second review completed on March 2, 2011. The spacecraft and instruments were checked out and prepared to successfully begin their mission. However, the Glory mission, which was launched from Vandenberg Air Force Base on March 4, 2011, did not reach orbit due to a mishap with the launch vehicle. Initial evidence suggests that the fairing, which protects the spacecraft during takeoff atop the Taurus XL launch vehicle, did not separate as required, when it reached the appropriate altitude. (See page 164 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015 launch at least three missions in support of this objective. | | | | | 2.1.5.3 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the ICESat-2 Spacecraft System Requirements Review. | None | None | 9ES16 Yellow | 10ES12 Green | ES-11-14 Yellow |
| ***Why NASA rated APG ES-11-14 Yellow:*** The date for the ICESat-2 Systems Requirements Review, has been delayed to December 2011. This review was rescheduled from March 2011 to revisit the mission design and requirements to align with the estimated available budget, moving forward. (See page 179 for the Performance Improvement Plan.) | | | | | |
| Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing. | 7ESS6 Yellow | 7ES04 Yellow | 9ES2 Green | 10ES22 Green | ES-11-3 Yellow |
| ***Why NASA rated APG ES-11-3 Yellow:*** The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. (See page 177 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.1.6.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in characterizing the dynamics of Earth's surface and interior and forming the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7ESS10 Green | 8ES11 Green | 9ES17 Green | 10ES13 Green | ES-11-15 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015 launch at least one mission in support of this objective. | | | | | 2.1.6.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Landsat Data Continuity Mission (LDCM) Mission Operations Review. | None | None | 9ES11 Green | 10ES08 Green | ES-11-8 Green |

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.1.7.1 Green |
| **FY 2011 Annual Performance Goals** | **FY 07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Conduct impact analyses of two projects that apply NASA Earth science research to support decision making activities. | 7ESS11 Green | 8ES012 Green | 9ES18 Green | 10ES14 Green | ES-11-16 Green |
| Increase the number of science data products delivered to Earth Observing System Data and Information System (EOSDIS) users. | None | 8ES13 Green | 9ES19 Green | 10ES15 Green | ES-11-17 Green |
| Maintain a high level of customer satisfaction, as measured by exceeding the most recently available federal government average rating of the Customer Satisfaction Index. | None | 8ES13 Green | 9ES20 Green | 10ES16 Green | ES-11-18 Green |
| | | | | | |
| | | | | | |
| **Uniform and Efficiency Measures** | | | | | |
| | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete all development projects within 110 percent of the cost and schedule baseline. | 7ESS21 Yellow | 8ES15 Yellow | 9ES21 Red | 10ES17 Red | ES-11-19 Red |
| ***Why NASA rated APG ES-11-19 Red:*** This annual performance goal was not met, due to cost and schedule growth that exceeded 10 percent of their estimated baseline for the NPOESS Preparatory Project (NPP), Glory and Aquarius missions. The NPP mission experienced delays due to the restructure of the project management and on-going development issues with an instrument, contributed by one of NASA's partners. The Aquarius mission was delayed by NASA's international partner, after the successful delivery of NASA's instrument contribution. The Glory mission had both instrument and spacecraft technical issues, across its development. (See page 176 for the Performance Improvement Plan.) | | | | | |
| Deliver at least 90 percent of scheduled operating hours for all operations and research facilities. | 7ESS22 Green | 8ES16 Yellow | 9ES22 Green | 10ES18 Green | ES-11-20 Green |
| Peer-review and competitively award at least 90 percent, by budget, of research projects. | 7ESS23 Green | 8ES17 Green | 9ES23 Green | 10ES19 Green | ES-11-21 Green |
| Reduce time within which 80 percent of NASA Research Announcement (NRA) research grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days. | 7ESS24 Red | 8ES18 Green | 9ES24 Red | 10ES20 Yellow | ES-11-22 Yellow |
| ***Why NASA rated APG ES-11-22 Yellow:*** This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Earth Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 33 days, approximately 16 percent of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. (See page 172 for the Performance Improvement Plan.) | | | | | |
| | | | | | |

# Outcome 2.2
## Understand the Sun and its interactions with Earth and the solar system.

Billions of years ago, at the core of the Sun, a nuclear furnace ignited. The energy the Sun provides, radiated almost constantly from its visible surface, is the basis of all advanced life on Earth. The Sun is a variable star, and its waxing and waning magnetic activity is the driver of space weather at Earth and across the solar system. Earth and the other planets reside in the extended atmosphere of the Sun. This extended atmosphere, called the heliosphere, comprises a plasma "soup" of electrified and magnetized matter entwined with penetrating radiation and energetic particles.

Heliophysics conducts missions that study the Sun, heliosphere, and planetary atmospheres as a single interconnected system. By analyzing these interconnections, scientists uncover fundamental physical processes that occur throughout the universe. These missions also improve capabilities for predicting the impacts of solar variability on human technological systems and safeguarding human and robotic space explorers outside the protective cocoon of Earth's atmosphere.



Sunspots, which are cooler, darker areas of intense magnetic activity, are most often the source of solar storms. On July 17 and 18, 2011, scientists using the Solar Dynamics Observatory (SDO) took observations of the Sun's lower atmosphere in extreme ultraviolet light and of the surface in filtered light to see the correlation of the sunspots to the brighter active regions above the surface. The loops above the sunspot regions reveal magnetic field lines pushing out from the Sun. View digital movies of this image. (Credit: SDO)

NASA's research in heliophysics has improved the understanding of space weather. NASA partners with the National Oceanic and Atmospheric Administration (NOAA) to serve the Nation's need for reliable space weather information. NASA spacecraft, equipped with space weather beacons, provide real-time data to NOAA space weather forecasters. NASA cooperates with other agencies to enable new knowledge in this area and to measure conditions in space critical to both operations and scientific research.

NASA's work to understand the causes and consequences of both short- and long-term changes in upper atmospheric density is important to satellite operators because atmospheric drag of these outermost layers significantly affects a satellite's orbit. Sudden increases in this density can cause satellite orbits to drop unexpectedly, making them difficult to track. Understanding the relative contribution of the Sun and other drivers on the upper atmosphere will improve predictions of densities and temperatures that are critical to plan satellite lifetime and the time for replacement. The unprecedented low values seen in conjunction with lowest sunspot counts of 2009 had an effect much greater than anticipated and scientists are working hard to understand both the processes involved and their consequences for space operations, forecasting orbital tracks, and predicting the orbital lifetime and decay of both satellites and space debris.

Heliophysics completed three important mission milestones in FY 2011:

- The Science Mission Directorate (SMD) completed the Preliminary Design Review (PDR) for the Magnetospheric Multiscale's (MMS') mission operations center and science operations center on June 9, 2011. The PDR ensured that the designs and systems selected for the centers were appropriate to mission needs, the risks had been assessed, and the estimated cost and schedule baselines were acceptable. MMS will use Earth's magnetosphere as a laboratory to study magnetic reconnection, a fundamental plasma-physical process that taps the energy stored in a magnetic field and converts it into heat and kinetic energy in the form of charged particle acceleration and large-scale flows of matter.
- A review team completed the Systems Integration Review (SIR) for the Radiation Belt Storm Probes (RBSP) on October 14, 2010. The SIR determined that all of RBSP's systems were working together and were ready to be integrated into the spacecraft bus for testing. RBSP will help scientists better understand the Sun's influence on Earth and near-Earth space by studying the planet's radiation belts on various scales of space and time.

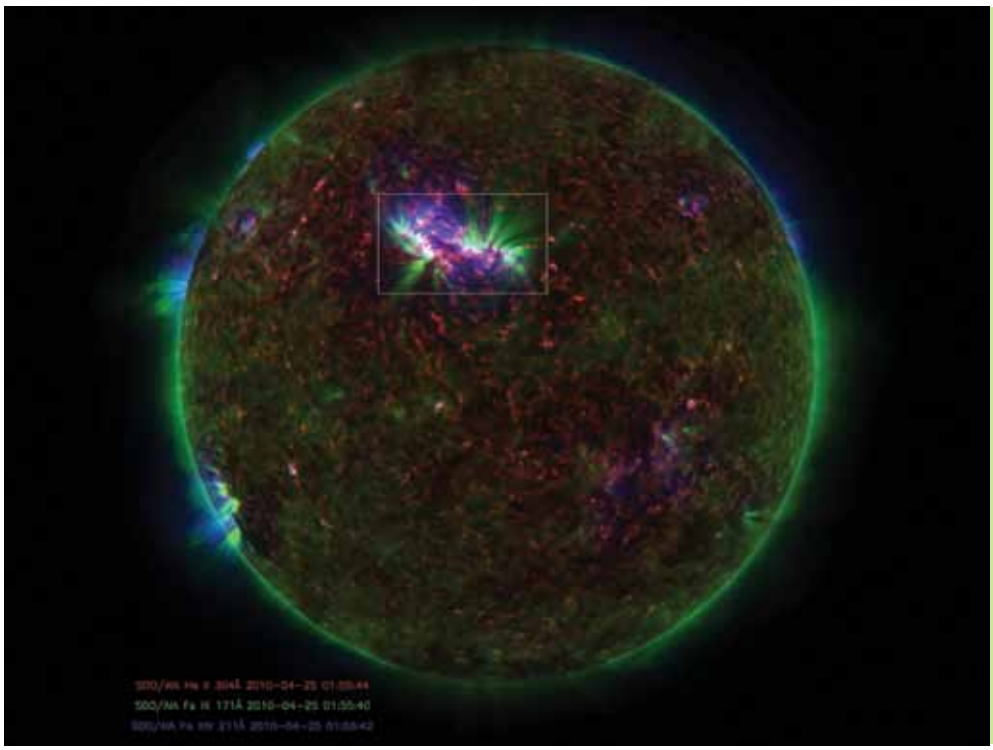
- The Interface Region Imaging Spectrograph (IRIS) mission completed its Critical Design Review (CDR) in February 2011, giving the project permission to begin final design and fabrication prior to the start of integration and testing. IRIS will resolve a fundamental challenge in heliophysics science by observing the Sun's chromosphere (the thin outer layer of gas) and transition region to understand how energy and plasma is transferred from the Sun into the solar wind.

## Gaining a better understanding of fundamental physical processes of the space environment

### *New SDO observations yield vital clues about dynamic coronal heating*

The plasma in the Sun's outer atmosphere (the corona) is mysteriously heated to millions of degrees, considerably hotter than the solar surface, or photosphere. Recent observations with NASA's Solar Dynamics Observatory (SDO) and a NASA instrument onboard the Japanese Hinode satellite have revealed how cool gas in the solar atmosphere is transferred into the corona while being heated to temperatures of millions of degrees, a pre-requisite for the formation of the solar wind. NASA is conducting this work as part of its objective to better understand fundamental physical processes of the space environment.

Cool gas in fountain-like jets, called spicules, are violently accelerated upward into the corona, with a small but significant fraction of the mass heated to much higher coronal temperatures. These results indicate that the Sun's chromosphere and corona are more tightly and dynamically coupled (transferring energetic particles between the two) than previously suspected. In fact, the corona itself may be populated and powered largely, if not entirely, by such energetic expulsions from the denser, cooler layers below. The physical process generally thought to drive these spicules is ultimately magnetic reconnection, a fundamental cause of magnetic energy release and reconfiguration throughout the heliosphere. Reconnection also is a prime suspect in triggering coronal mass ejections and heating their entrained plasma. (Read more about this story.)



Spicules on the Sun jet off the surface of the Sun at 150,000 miles per hour. Research resulting from Hinode and SDO observations suggests that the spicules contain the gas that reaches temperatures over a million degrees, as observed in the solar corona. This composite SDO image, taken in various ultraviolet wavelengths, highlights resulting temperature differences in the million-degree corona. (Credit: NASA Goddard/ SDO/AIA)

### *Identifying the driver of pulsating aurorae*

Typical aurorae stretch more than 600 miles in length and last minutes at a time. Pulsating aurorae are small glowing patches of light only about 60 miles wide that flash on and off every 5 to 40 seconds. This flickering gives the appearance of exploding lights in the sky. Determining the cause of these pulsations has been a longstanding goal for over four decades. Using simultaneous aurora and spacecraft plasma wave observations, NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission has solved the mystery. When solar wind strikes Earth's

magnetic field, the wind induces electromagnetic waves in the near-space environment. A particular type of these waves, chorus, is able to interact with electrons in Earth's magnetic field, sending them downwards into the atmosphere and creating the pulsating aurora's light show much in the same way that a cathode ray tube creates images on the screens of older model televisions. NASA's THEMIS team discovered that these chorus waves appear at regular intervals in the same locations as the patches of light; the stronger the waves, the brighter the light. The data from THEMIS is helping NASA achieve its objective of improving understanding of the fundamental physical processes of the space environment from the Sun to Earth.

### *Observations of the lunar wake: refilling one of nature's natural vacuums*

Heliophysics redirected two small satellites, originally launched into Earth orbit in 2007, into new orbits around the Moon to study the Moon's interactions with the solar wind. Both spacecraft were previously in an area called the Lagrangian points, or points on either side of the Moon where the Moon and Earth's gravity balance. This location is ideal for studying magnetism near the moon and how the solar wind—made up of ionized gas known as plasma—flows past the Moon and tries to fill in the vacuum on the other side.

The two spacecraft, together renamed the Acceleration, Reconnection, Turbulence and Electrodynamics of the Moon's Interaction with the Sun (ARTEMIS) mission, have been making detailed observations of the Moon's plasma wake—a turbulent cavity carved out of the solar wind by the Moon itself, akin to the wake behind a speedboat. The Moon essentially is a non-magnetic, non-conducting obstacle in space that has no ionosphere. Solar wind plasma is absorbed on the Moon's dayside, leaving a plasma void on the night side. ARTEMIS scientists have discovered particle beams entering and refilling the lunar wake, along with plasma waves that occur in conjunction with these beams. This work will allow scientists to determine how the solar wind electrifies, alters, and erodes the surface of similar bodies in the solar system. (Read more about this story.)

### *Space Shuttle plume motion demonstrates presence of unexpectedly high winds in the upper atmosphere*

Space Shuttle and rocket launches burn many metric tons of liquid oxygen and liquid hydrogen as they ascend to orbit, generating extensive water vapor plumes in the upper atmosphere. The plumes can survive for several days and provide an important opportunity to trace upper atmospheric wind dynamics.

NASA's Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) spacecraft recently documented the path of a Space Shuttle plume and observed unexpectedly intense and long-lasting upper atmospheric winds propelling the plume southward to the Antarctic peninsula. While the speed and scale of the movement was entirely unanticipated, the dynamics could be reproduced in models of the upper atmosphere. Scientists hypothesize that large-scale waves in atmospheric density and temperature are able to produce the measured wind speeds of nearly 80 miles per second. Such studies are important to understand the processes controlling the terrestrial upper atmosphere and provide an explanation for the relatively common occurrence of extreme winds in Earth's lower thermosphere, the second to last layer of Earth's atmosphere, where auroras occur and the International Space Station orbits.

## Understanding how solar variability affects society, technology, and the habitability of other planets

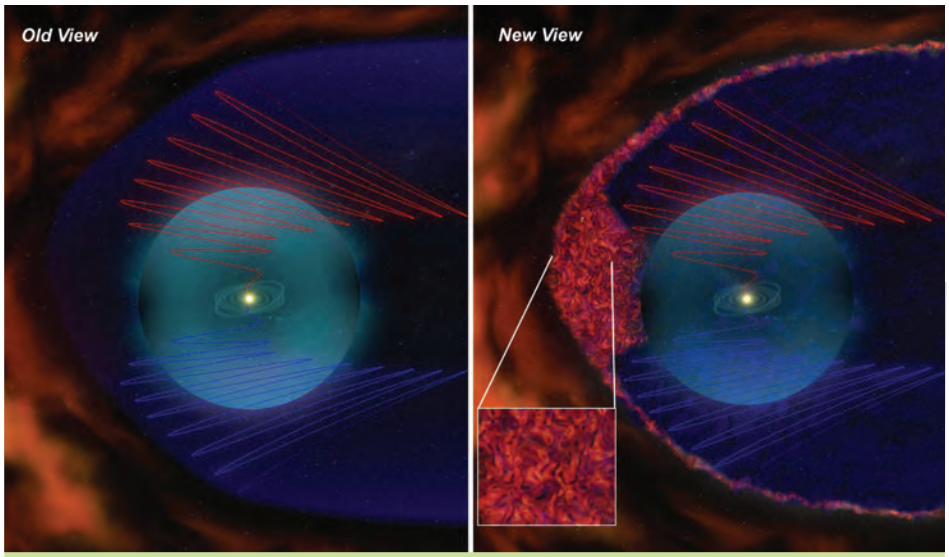
### *New understanding of how radiation belt electrons are accelerated to their high energies*

The Van Allen Radiation Belts (volumes of energetic charged particles, or plasma, held in pace by Earth's magnetic field) are the most extreme radiation environment encountered by Earth-orbiting satellites. High-energy electrons in the outer radiation belt wreak havoc on satellite electronics, but just how these electrons are energized has been unclear. New NASA-funded studies using wave and particle measurements by the European Space Agency's Cluster mission have shed light on the initiation of this process: plasma waves generated by low-energy plasma in turn accelerate the relativistic electrons.

NASA's Wind spacecraft measurements have made the first detailed measurements of the acceleration process in the solar wind. Studying Wind observations provided the rare opportunity to examine this chain of physics in action, thus answering how waves are excited and can ultimately accelerate electrons to the relativistic energies such as observed in the radiation belts. The Radiation Belt Solar Probe (RBSP) mission, scheduled for launch in 2012, will provide the definitive measurements to understand radiation belt generation and degradation. Its data will help NASA achieve its objectives of better understanding the fundamental physical processes of the space environment and better understanding of human society and how life on Earth is affected by solar events.

### *Discoveries at the edge of the solar system*

After 33 years of travel and traveling nearly one-million miles per day, the Voyager-1 spacecraft has reached the outermost region of the heliosphere where the outward speed of the solar wind has slowed to zero. This indicates that the last boundary before entering interstellar space, the heliopause, is nearby. Scientists have used measurements taken by Voyager-1 and its sister ship, Voyager-2, as they travel through the so-called heliosheath with theoretical modeling to create a completely new picture of this region, characterized as a "frothy mix" of magnetic bubbles produced by reconnection among the weak tendrils of the solar magnetic field. (More on the Voyagers' findings.)




In the old view of the heliosheath represented on the left, red and blue spirals represent the gracefully curving magnetic field lines. The new model (right) shows that because the Sun spins, its magnetic field becomes twisted and wrinkled. Far away from the Sun, where the Voyagers are now, the folds bunch up. When a magnetic field gets severely folded, lines of magnetic force criss-cross, and "reconnect." (Magnetic reconnection is the same energetic process underlying solar flares.) The crowded folds reorganize themselves, sometimes explosively, into foamy magnetic bubbles, shown in the inset. (Credit: NASA)

Whereas the two Voyager spacecraft delivered two in-situ point measurements of the heliosheath, NASA's Interstellar Boundary Explorer (IBEX) simultaneously produced a global picture from a near-Earth orbit, through images produced by energetic neutral atoms. Energetic neutral atoms of hydrogen are created where the solar wind interacts with the interstellar medium, both inside and beyond the heliosphere. Together, the Voyager and IBEX discoveries are stimulating a new quantitative understanding of how the heliosphere couples to interstellar space and the consequences of that interaction for the space ionizing radiation environment at Earth and elsewhere in the solar system. (More on IBEX's finds at the solar boundary.)

### *Earth's near space environment is never truly quiescent*

Though the last solar minimum was the quietest of the space age, there was still substantial activity in Earth's near space environment. This activity differed in significant ways, however, from the activity associated with solar maximum conditions. Unlike solar maximum storms, which are driven largely by coronal mass ejections, during solar minimum corotating interaction regions (CIRs), high-speed streams in the solar wind that recur each solar rotation, are the primary contributor to the recurrent geomagnetic activity at Earth. Even during the calmest of solar conditions, these CIRs can drive substantial density changes in the upper atmosphere. Observations from the German Challenging Mini-Satellite Payload (CHAMP) satellite have shown that the thermosphere density responds to high-speed streams globally, and the density at 249 mile (400 kilometer) altitude changes by 75 percent on average. CIRs also can trigger substorms and particle acceleration in geospace, changing the configuration of the inner magnetospheric ring current. The Two Wide-angle Imaging Neutral-atom Spectrometers (TWINS) observations of numerous solar minimum CIR-driven storms have shown some significant and interesting differences from coronal mass ejection-driven storms and demonstrated that during the post-storm recovery, the global ring current energy density falls much more rapidly than would be expected based on ground-based magnetometer measurements.

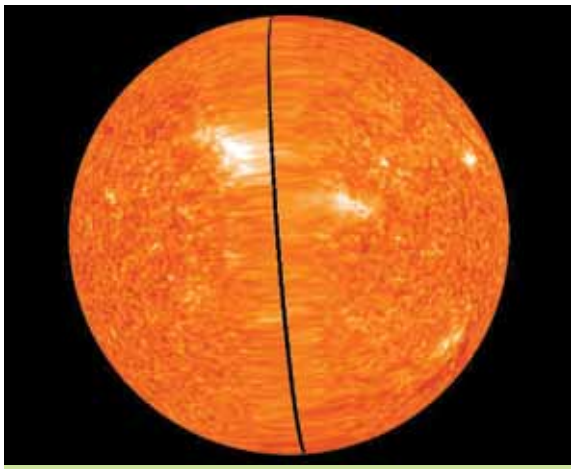
### *Improved space weather prediction—from a phone*

A few hours before a gigantic bubble of electrified gas and charged particles erupted from the Sun, NASA officially released the new Space Weather App, making images and other data almost immediately available to users.

A fast-moving mass ejection from the Sun raced through space at 1,242 miles per second, and while it did not strike Earth directly, the eruption did trigger a run at the iTunes store. Within just a couple of days, 1,500 users had already downloaded the application, making it one of the store's 20 most popular in the weather category. (Read more about the Space Weather App.)

### *First-ever images of the entire Sun reveal that activity can involve much more than is visible from Earth*

On February 6, NASA's twin STEREO spacecraft moved into position on opposite sides of the Sun. They are now beaming down images which, combined with those from the Earth-orbiting SDO, show the entire solar sphere—front and back—without interruptions. This unprecedented view has revealed connections previously unseen and helping NASA researchers better predict extreme and dynamic conditions in space.



This image, taken February 2, 2011, of the far side of the Sun based on STEREO data, still shows a small gap between the STEREO Ahead and Behind data. On February 6, the spacecraft achieved 180-degree separation, closing the gap. (Credit: NASA)

Researchers long suspected that solar activity can "go global," with eruptions on opposite sides of the Sun triggering and feeding off of one another. Now they have actually studied the phenomenon. The Great Eruption of August 2010 engulfed about two thirds of the solar surface with dozens of mutually interacting flares, shock waves, and reverberating filaments. Much of the action was visible from Earth's perspective, including SDO, but some was hidden behind the limb (where the curve of Earth meets the blackness of space) and only visible to the STEREO spacecraft looking at the Sun from different angles.

Studies of these coupled phenomena provide warnings of solar active regions producing flares, coronal mass ejections, and energetic particles before they are visible from Earth. The global solar view also yields space weather situational awareness throughout the solar system. For example, STEREO observations from the far side of the Sun provided warning of a coronal mass ejection that struck NASA's MESSENGER spacecraft a glancing blow as it was being inserted into orbit around the planet Mercury.

### *Space Weather Shock Forecasts*

In partnership with NOAA, NASA has developed a computer program to provide near real-time identification of interplanetary shocks waves created by coronal mass ejections from the Sun. Interplanetary shocks are known to be major drivers of geomagnetic storms. The new computer program automatically searches magnetic field and solar wind data from NASA's Advanced Composition Explorer (ACE) to provide advanced warning for the arrival of interplanetary shocks at Earth. In some cases, the shock conditions can be identified within ten minutes after the solar wind plasma impacts the ACE spacecraft, which is located upstream of the solar wind between the Sun and Earth. As a result of this improved shock detection method, space weather forecasters can now better utilize the 15 to 45 minutes of advance warning prior to the shock's collision with Earth's magnetopause. This work provides a significant improvement from previous forecast models.

| **Outcome 2.2** | | | | | |
|---|---|---|---|---|---|
| Understand the Sun and its interactions with Earth and the solar system. | | | | | |
| | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | **2.2.1.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding the fundamental physical processes of the space environment from the Sun to Earth, to other planets, and beyond to the interstellar medium. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | **7ESS13 Green** | **8HE01 Green** | **9HE1 Green** | **10HE01 Green** | **HE-11-1 Green** |

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| By 2015, launch two missions in support of this outcome. | | | | | 2.2.1.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Magnetospheric MultiScale (MMS) Mission Operations Center and Science Operations Center Preliminary Design Review. | 7ESS15 Red | 8HE02 Green | 9HE2 Green | 10HE02 Green | HE-11-2 Green |
| Complete the Geospace Radiation Belt Storm Probes Systems Integration Review. | 7ESS16 Green | 8HE04 Green | 9HE3 Green | 10HE03 Green | HE-11-3 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.2.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding how human society, technological systems, and the habitability of planets are affected by solar variability interacting with planetary magnetic fields and atmospheres. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7ESS19 Green | 8HE03 Green | 9HE6 Green | 10HE06 Green | HE-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch two missions in support of this outcome. | | | | | 2.2.2.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Magnetospheric MultiScale (MMS) Mission Operations Center and Science Operations Center Preliminary Design Review. | 7ESS15 Red | 8HE02 Green | 9HE2 Green | 10HE02 Green | HE-11-2 Green |
| Complete the Geospace Radiation Belt Storm Probes Systems Integration Review. | 7ESS16 Green | 8HE04 Green | 9HE3 Green | 10HE03 Green | HE-11-3 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.2.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in maximizing the safety and productivity of human and robotic explorers by developing the capability to predict the extreme and dynamic conditions in space. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7ESS20 Green | 8HE05 Green | 9HE8 Green | 10HE08 Green | HE-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2017, launch at least two missions in support of this outcome. | | | | | 2.2.3.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Geospace Radiation Belt Storm Probes Systems Integration Review. | 7ESS16 Green | 8HE04 Green | 9HE3 Green | 10HE03 Green | HE-11-3 Green |
| | | | | | |
| | | | | | |
| **Uniform and Efficiency Measures** | | | | | |
| | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete all development projects within 110 percent of the cost and schedule baseline. | 7ESS21 Yellow | 8HE07 Red | 9HE10 Yellow | 10HE09 Red | HE-11-6 White |
| ***Why NASA rated APG HE-11-6 White:*** The metric indicates the final development costs, once a mission launches, but there were no planned launches for FY 2011 in Heliophysics. Hence the measure is not applicable to this fiscal year, and rated white.. | | | | | |
| Deliver at least 90 percent of scheduled operating hours for all operations and research facilities. | 7ESS22 Green | 8HE08 Green | 9HE11 Green | None | HE-11-7 Green |
| Peer-review and competitively award at least 90 percent, by budget, of research projects. | 7ESS22 Green | 8HE09 Green | 9HE12 Green | None | HE-11-8 Green |
| Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days. | 7ESS24 Red | 8HE10 Yellow | 9HE13 Green | 10HE12 Red | HE-11-9 Green |

# Outcome 2.3

## Ascertain the content, origin, and evolution of the solar system and the potential for life elsewhere.

Planetary Science's missions have revolutionized understanding of the origin and history of the solar system. NASA has missions circling the innermost planet, Mercury, and heading for the outer reaches of the solar system, where Pluto orbits among many Kuiper Belt objects. Its missions have orbited and roved the surface of Mars, finding evidence of liquid water. Closer to home, Planetary Science uses ground-based sensors in coordination with the National Science Foundation and the U.S. Air Force to survey the volume of near-Earth space to detect, track, catalog, and characterize near-Earth objects that may either pose hazards to Earth or provide destinations and resources for future exploration.

NASA's robotic science missions are paving the way for understanding the origin and evolution of the solar system and identifying past and present habitable locations. With this knowledge, NASA is enabling human space exploration by studying and characterizing planetary environments beyond Earth and identifying possible resources that will enable safe and effective human missions to destinations beyond low Earth orbit.

Robotic explorers gather data to help scientists understand how the planets formed, what triggered different evolutionary paths among planets, what processes are active, and how Earth formed, evolved, and became habitable. To search for evidence of life beyond Earth, scientists use this data to map zones of habitability, study the chemistry of unfamiliar worlds, and unveil the processes that lead to conditions necessary for life.

Planetary Science completed some important milestones this fiscal year:

- In August 2011, NASA completed the Juno Launch Readiness Review, the last review of the spacecraft, its launch vehicle, and launch systems. The mission launched on August 5, beginning its five-year journey to Jupiter. At the end of the month, the mission team began checking the spacecraft's camera by taking images of Earth and the Moon (for more information, go to the news release). Planetary Science completed Juno development within the lifecycle estimate for both cost and schedule.
- NASA completed the Gravity Recovery and Interior Laboratory (GRAIL) mission Pre-Ship Review on May 5, 2011. This review was a quality check conducted before the two spacecraft were shipped from the contractor that built them to NASA for launch preparations. On September 10, GRAIL launched on its way to the Moon to begin mapping lunar gravity and using that information to increase understanding of the Moon's interior and thermal history. Planetary Science completed GRAIL development within the estimated life cycle for both cost and schedule.
- NASA completed the Confirmation Review for the Mars Atmosphere and Volatile Evolution Mission (MAVEN) on October 4, 2010. This review determined that the project team had successfully formulated a plan that established the project purpose, scope, parameters, deliverables, and providers, assessed risk, and estimated a lifecycle cost and schedule that covered these elements. With the review completed, MAVEN entered development, when the spacecraft is built and tested. In July, MAVEN passed another critical milestone when an independent review board, composed of reviewers from NASA and several external organizations, met to validate the

As the Sun comes up over Cape Canaveral Air Force Station in Florida on August 5, 2011, preparations are under way at Space Launch Complex 41 to launch the Atlas V-551 launch vehicle carrying NASA's Juno spacecraft. (Credit: NASA/K. Allen)

system design as part of the Critical Design Review. This review granted permission to the mission team to begin manufacturing hardware. MAVEN will provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses.

- The Jet Propulsion Laboratory completed the Mars Science Laboratory (MSL) Pre-Ship Review on May 5, 2011, and pressed ahead with launch preparation activities. System testing put the rover and other parts of the spacecraft through simulations of many activities from launch through operations on Mars' surface.

Below is a sample of FY 2011 activities that supported this outcome.

## Understanding the formation, evolution, and behavior of solar system objects

### *WISE has a second career hunting for asteroids*

While the Wide-field Infrared Survey Explorer (WISE), launched in December 2009, was performing its prime mission—scanning the entire sky to build a detailed map in the infrared—its tens of thousands of images were also being examined to find objects in our own solar system. It proved to be particularly useful for finding near Earth objects (NEOs), asteroids and comets with orbits that come within 28 million miles of Earth's path around the Sun and that may pose an impact hazard. This "NEOWISE" project of the WISE mission was dedicated to hunting for asteroids and comets. In early October 2010, WISE ran out of the coolant that keeps its instrumentation cold, but two of its four infrared detectors remained operational, and these two channels were used to complete the one year entire scan around the solar system.

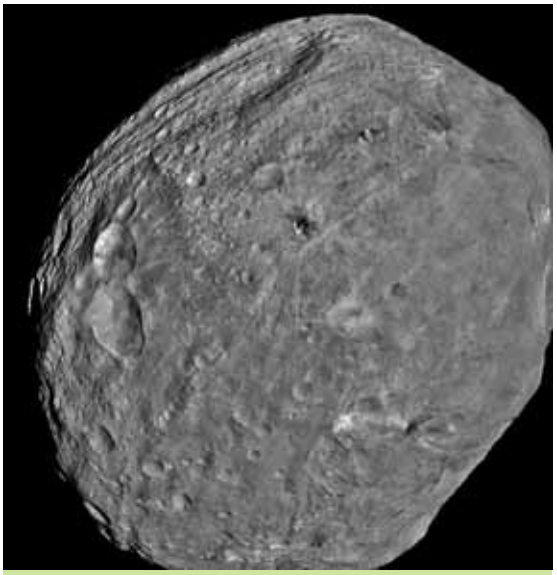
By the end of survey operations in February 2011, the NEOWISE researchers observed over 157,000 asteroids, including more than 585 NEOs, and 120 comets. The mission's discoveries of previously unknown objects include 20 comets, more than 33,000 asteroids in the main belt between Mars and Jupiter, and 134 NEOs. NEOWISE also observed objects farther away than the main belt: about 2,000 asteroids that orbit ahead and behind Jupiter, the so-called Trojan asteroids.

These observations will be key to determining the objects' sizes and compositions. Visible-light data reveals only how much sunlight reflects off an asteroid, but infrared data is directly related to the object's size and provides much more accurate estimates. By combining visible and infrared measurements, astronomers also can learn more about the size and compositions of the rocky bodies, for example, whether they might be solid or crumbly. The findings will lead to a much-improved picture of the various asteroid populations.

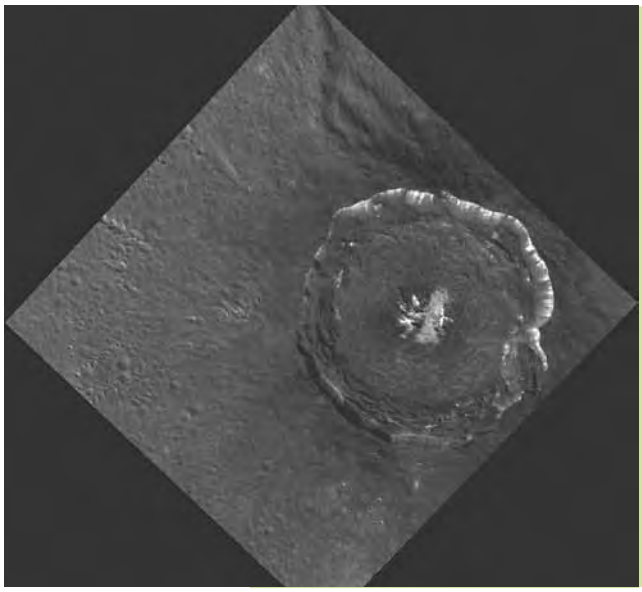
### *Dawn enters into orbit around Vesta*

The Dawn spacecraft, after a 1.7 billion mile journey, slipped into orbit around Vesta on July 15, starting a yearlong science campaign to map one of the solar system's largest asteroids. Images taken in the High-Altitude Mapping Orbit show that the surface of Vesta appears to be much rougher than other asteroids in the main asteroid belt. Preliminary dates from a method that uses the number of craters indicate that areas in the southern hemisphere are as young as 1 to 2 billion years old, much younger than areas in the north. One spectacular image shows a mountain three times as high as Mt. Everest, amidst the topography in the south polar region, rising about 13 miles (22 kilometers) above the average height of the surrounding terrain, making it one of the tallest mountains in the solar system. Dawn is the first spacecraft to enter orbit around a main asteroid belt object, use an ion engine on a NASA planetary mission, and visit an asteroid thought to be the source of many meteorites found here on Earth. (Read more about Dawn arriving at Vesta.)

Dawn's goal is to characterize the conditions and processes of the solar system's earliest epoch by investigating in detail two of the largest asteroids hypothesized to once have been protoplanets remaining intact since their formation: Vesta and Ceres. Protoplanets were small bodies that collided to gradually form dominant planets during the early development of a solar system. Dawn is investigating Ceres and Vesta to learn more about the evolutionary paths they followed.



On July 24, 2011, NASA's Dawn spacecraft obtained this image, taken from a distance of about 3,200 miles, of the giant asteroid Vesta with its framing camera. Dawn entered orbit around Vesta on July 15 and will spend a year orbiting the body. After that, the next stop on its itinerary will be an encounter with the dwarf planet Ceres. (Credit: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA)



This MESSENGER image, acquired in May 2011, provides an extraordinary view of the crater Degas on Mercury. The crater's floor contains cracks that formed as the pool of impact melt cooled and shrank. The high-reflectance material on the walls and in the central portion of the crater probably has a composition distinct from that of the crater floor and surroundings. The illumination conditions and down-slope movement of eroded material exposing fresh rock also contributed to the bright appearance. (Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington)

## Understanding the origin and evolution of the solar system's planets, moons, and bodies

### *MESSENGER reaches Mercury orbit insertion and begins orbital observations*

MESSENGER (Mercury Surface, Space Environment, Geochemistry and Ranging), the first spacecraft to orbit Mercury, reached orbit insertion at the solar system's innermost planet on March 17, 2011, and sent its first image from orbit on the 29th, beginning the first up-close study of the smallest planet.

MESSENGER will map the entire surface of Mercury and monitor changes in the planet's atmosphere. Mercury is one of four terrestrial (rocky) planets in the solar system, along with Earth, Venus, and Mars. Among these four, it is a planet of extremes: it is the smallest, the densest, the one with the largest daily variations in surface temperatures, the one with the oldest surface, and the least explored. Understanding this extreme terrestrial planet is key to understanding how the planets in the solar system formed and evolved.

Scientists are discovering that many previous theories based on earlier flybys by MESSENGER and by Mariner 10 in the 1970s must now be revisited due to results coming in from MESSENGER's orbital observations. Exciting new results include evidence that Mercury may have experienced explosive volcanic activity in its past on a global scale and images showing a new class of features called "hollows," fresh-appearing, irregular, shallow, rimless depressions. (See the September 30, 2011, issue of *Science* for more on these results.)

### *Juno on a mission to discover the origin of the solar system*

On August 5, 2011, NASA launched the Juno spacecraft on its mission to study the solar system's largest planet, Jupiter. Underneath this gas giant's dense cloud cover are secrets to the fundamental processes and conditions that governed the solar system during its formation. Theories about solar system formation all begin with the collapse of a giant cloud of gas and dust, or nebula, most of which formed the infant Sun. Like the Sun, Jupiter is mostly hydrogen and helium, so it likely formed early, capturing material left after the Sun was born. Scientists have posed different scenarios for how this may have happened: a massive planetary core formed first and gravitationally captured gas, or an unstable region collapsed inside the nebula, triggering the planet's formation. Juno may provide the data needed to understand how the solar system formed.

As the primary example of a giant planet, Jupiter also can provide critical knowledge for understanding the planetary systems being discovered around other stars, which frequently have one or more one or more Jupiter-sized or super-Jupiter planets. With its suite of science instruments, Juno will investigate the existence of a solid planetary core, map Jupiter's intense magnetic field, measure the amount of water and ammonia in the deep atmosphere, and observe the planet's auroras.

### *Water, discovered in lunar rocks, raises questions about origin of the Moon*

In May 2011, a team of NASA-funded researchers published their findings that they measured, for the first time, water from the Moon contained in tiny globules of molten rock, which have turned to glass-like material trapped within crystals. Data from these lunar melt inclusions indicate the water content of lunar magma was 100 times higher than previous studies suggested, and confirm that the Moon is not as dry as previously thought. The higher water content has implications for the origin of the Moon and may shed light on how the inner planets acquired their water.

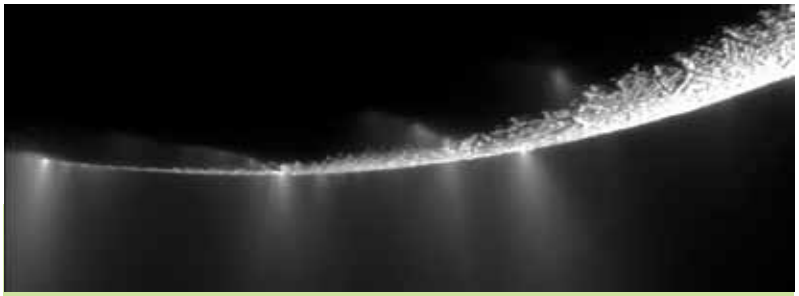
The inclusions were found in a sample collected during the Apollo 17 mission in 1972. The scientific team used a state-of-the-art ion microprobe instrument to measure the water content of the inclusions contained within the famous "orange glass soil" formed during explosive eruptions about a 3.7 billion years ago.

The results raise questions about aspects of the "giant impact theory" of how the Moon was created. That theory predicted that a catastrophic collision between Earth and a Mars-sized body very early in Earth's history would have produced a Moon with very low water content. The energetic collision would have stripped away volatiles, "degassing" the resultant early Moon. The team's work, however, shows that at least parts of the lunar interior had as much water as parts of Earth's current interior. The study also puts a new twist on the origin of water-ice detected in craters at the lunar poles by several recent NASA missions, including the Lunar Reconnaissance Orbiter (LRO) and the Lunar Crater Observation and Sensing Satellite (LCROSS). The ice has been attributed to comet and asteroid impacts, but the researchers think it is possible that some of the ice came from water released by the eruption of lunar magmas eons ago. (Read more on the lunar water study.)

## Discovering the history and habitability of Mars and other solar system bodies

### *Enceladus' ocean-like spray indicates salt water reservoir*

NASA's Cassini spacecraft has discovered the best evidence yet for a large-scale salt-water reservoir beneath the icy crust of Saturn's moon Enceladus. The data came from the spacecraft's direct analysis of salt-rich ice grains close to the jets ejected from the moon.



Dramatic plumes, both large and small, spray water ice out from many locations along the famed "tiger stripes" near the south pole of Saturn's moon Enceladus. The tiger stripes are fissures that spray icy particles, water vapor and organic compounds. More than 30 individual jets of different sizes can be seen in this mosaic, created from two high-resolution images that were captured by Cassini's narrow-angle camera when the spacecraft flew past Enceladus and through the jets on November 21, 2009. (Credit: NASA/JPL/Space Science Institute)

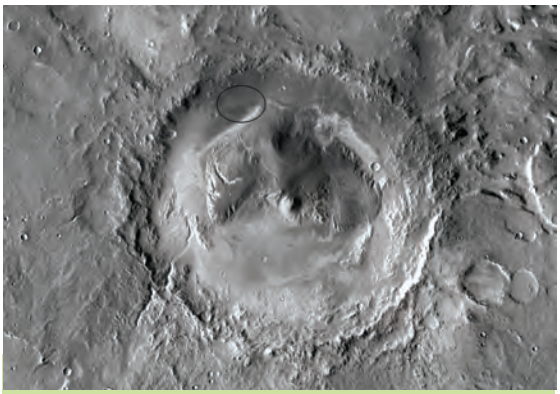
The discovery of plumes of water vapor and ice particles from warm fractures, known as tiger stripes, raised the question of whether the plumes were emerging from a subsurface liquid source or from the decomposition of ice. New analysis from Cassini's cosmic dust analyzer instrument, and published in the June issue of *Nature*, found that relatively large grains rich with sodium and potassium dominate the plumes. The salt-rich particles have an "ocean-like" composition that indicate that most, if not all, of the expelled ice and water vapor comes from the evaporation of liquid salt water.

This analysis suggests a layer of water between the moon's rocky core and its icy mantle, possibly as deep as about 50 miles beneath the surface. As this water washes against the rocks, it dissolves salt compounds and rises through fractures in the overlying ice to form reserves nearer the surface. If the outermost layer cracks open, the decrease in pressure from these reserves to space causes a plume to shoot out. The authors suggest the water reserves must have large evaporating surfaces, or they would freeze easily and stop the plumes. Liquid water is one of the prerequisites for known forms of life, making Enceladus another target of interest for studies of past or current habitability. (Read more on this story.)

### *Landing site selected for upcoming Mars mission*

On June 22, 2011, NASA announced Gale crater as the landing site for the Mars Science Laboratory's (MSL's) car-sized rover, *Curiosity*. This was one of the important last milestones for preparing the mission for launch, achieving half of the requirements for Performance Goal 2.3.3.2. About the combined area of Connecticut and Rhode Island, Gale crater offers diverse stratigraphy (or rock layering), including possible water-bearing materials like sulfates and phyllosilicates, that suggests it is the surviving remnant of an extensive sequence of deposits. (Read more about the site selection.)

NASA is preparing MSL for launch during the first quarter of FY 2012. In a prime mission lasting one Martian year (nearly two Earth years), researchers will use the rover's tools to study whether the landing region has had environmental conditions favorable for supporting microbial life and for preserving clues about whether life existed.



The ellipse superimposed on this image of Gale crater indicates the intended landing area for the MSL rover, *Curiosity*. The portion of the crater within the landing area has an alluvial fan likely formed by water-carried sediments. The lower layers of the nearby mountain—within driving distance for Curiosity—contain minerals indicating a wet history. (Credit: NASA/JPL-Caltech/ASU)

## Study Earth to determine if there is or ever has been life elsewhere in the universe

### *More asteroids could have made life's ingredients*

A wider range of asteroids was capable of creating the kind of amino acids used by life on Earth, according to NASA Astrobiology Institute (NAI)-funded researchers.

In 2009, the team from the Goddard Center for Astrobiology reported the discovery of an excess of the left-handed form of the amino acid, isovaline, in samples of meteorites that came from carbon-rich asteroids. In a paper published in the December 2010 issue of *Meteoritics and Planetary Science*, the team reports finding excess left-handed isovaline (L-isovaline) in a much wider variety of carbon-rich meteorites. Amino acid molecules can be built in two ways that are mirror images of each other. Life on Earth uses left-handed amino acids, and they are never mixed with right-handed ones, but the amino acids found in the meteorite had equal amounts of the left and right-handed varieties.

Researchers recovered the asteroid remnants, collectively called Almahata Sitta, in the Sudanese desert in 2008, an example of ureilite meteorites (a rare, stony meteorite that has a high percentage of carbon in the form of graphite and nanodiamonds) found in pristine condition. A sample was divided between the Goddard Space Flight Center and a laboratory at the Scripps Institution of Oceanography at the University of California, San Diego. The extremely sensitive equipment in both labs detected small amounts of 19 different amino acids in the sample, ranging from 0.5 to 149 parts per billion. The authors suggest that the amino acids may have formed through reactions in gases as the very hot asteroid cooled down. The team had to be sure that the amino acids in the meteorite did not come from contamination by life on Earth.

Amino acids are used to make proteins, the workhorse molecules of life, used in everything from structures like hair to enzymes, the catalysts that speed up or regulate chemical reactions. Life uses 20 different amino acids in a huge variety of arrangements to build millions of different proteins. Some researchers hypothesize that ureilite meteorites were formed in the solar nebula, suggesting that the amino acids found in the Almahata Sitta samples might have been synthesized very early in the history of the solar system. (Read more on this story.)

### *A bacterium that can grow by using arsenic instead of phosphorus*

Life uses a combination of the elements carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur. Other elements may be present, but these six are the most common and essential for biological molecules.

NASA-funded researchers conducting tests in the harsh environment of Mono Lake, California, discovered the first known microorganism on Earth able to thrive and reproduce using the normally toxic chemical arsenic in place of phosphorus. Phosphorus is a central component of the energy-carrying molecule in all cells and also the phospholipids that form all cell membranes. Arsenic, which is chemically similar to phosphorus, disrupts metabolic pathways because chemically it behaves like phosphate.

The results of this study will inform ongoing research in many areas, including the study of Earth's evolution, organic chemistry, biogeochemical cycles, disease mitigation and Earth system research. They also will open new frontiers in microbiology and other disciplines. (Read more about this study.)

## Identify and learn about small solar system bodies

### *Finding near Earth objects*

NASA and its partners maintain a watch for near-Earth objects, asteroids and comets that pass close to Earth, as part of an ongoing effort to discover, catalog, and characterize these potentially hazardous objects. This fiscal year, asteroid search teams funded by NASA's Near Earth Object Observation Program found another twelve asteroids larger than one kilometer, or 0.62 miles, in size with orbits coming within Earth's vicinity.

Near-Earth objects pose a threat to property, the environment, and even life itself. Near-Earth objects that are one kilometer in diameter or larger pose the biggest overall hazard, because if they do impact it would have global consequences, including ejected debris spread around the Earth and into its atmosphere, blocking sunlight for many months to years. Smaller objects pose a more frequent hazard because with their much greater numbers they are the most likely to impact Earth. All of these objects hold great scientific interest because they represent relatively unchanged debris from the solar system formation process some 4.6 billion years ago. They may carry with them ice and the building blocks of life. NASA funds teams that detect and catalogue near-Earth objects for both planetary protection and scientific purposes.

Asteroid search teams also found one more near Earth comet and 959 smaller asteroids of less than one kilometer in average diameter, bringing the total number known of all sizes to 8,294. The high precision orbit predictions computed by NASA's Jet Propulsion Laboratory show that none of these objects are likely to hit Earth in the next century. However, 1,250 (of which 150 are larger than one kilometer in diameter) are in orbits that could become a hazard in the more distant future and warrant continued monitoring.

The results of the NEOWISE project, discussed earlier, complete and confirm the achievement this year of the initial "Spaceguard" goal, set with Congress back in 1998, to find at least 90 percent of the one kilometer and larger NEOs. NEOWISE analysis shows our search teams have now found 911 (+17) of 981 (+19), or 93 percent of the one kilometer and larger population (see story here).

### *NASA selects New Frontiers 3 mission—OSIRIS-REx*

In May 2011, Planetary Science selected an asteroid sample return as the third mission for its New Frontiers Program of solar system explorations. The Origins-Spectral Interpretation-Resource Identification-Security–Regolith Explorer, or OSIRIS-REx, will be the first U.S. mission to retrieve and carry materials from an asteroid back to Earth. Planned for launch in 2016, the spacecraft will use a robotic arm to collect samples that could better explain the solar system's formation and how life began.

Asteroids are leftovers formed from the cloud of gas and dust—the solar nebula—that collapsed to form the Sun and the planets about 4.6 billion years ago. As such, they contain the original material from the solar nebula, which can tell scientists about the conditions of the solar system's birth.

After rendezvous and acquisition of a sample, OSIRIS-REx will store the material in a capsule to be returned to Earth in 2023. The capsule's design will be similar to that used by NASA's Stardust spacecraft, which returned the world's first comet particles from comet Wild 2 in 2006. (Read more about the mission selection.)

## Outcome 2.3

Ascertain the content, origin, and evolution of the solar system and the potential life elsewhere.

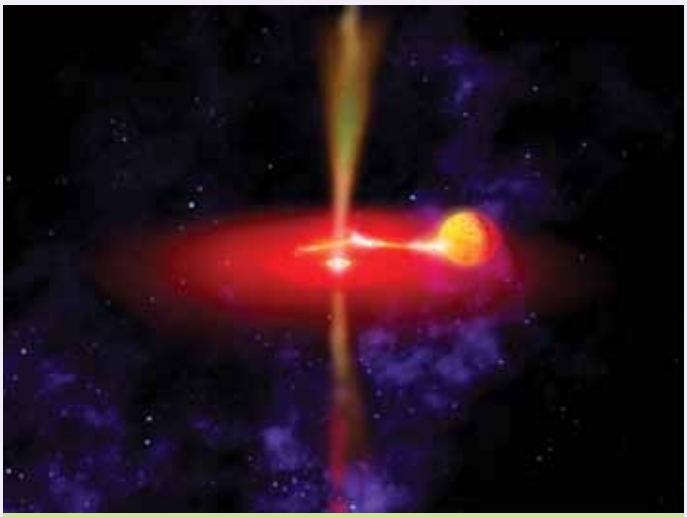
| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.3.1.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in inventorying solar system objects and identifying the processes active in and among them. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | None | None | None | None | PS-11-1 Green |
| Achieve arrival of Dawn at Vesta. | None | None | None | None | PS-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2017, launch at least two missions in support of this outcome. | | | | | 2.3.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the mission concept studies for the New Frontiers 3 mission. | None | None | None | 10PS04 Green | PS-11-3 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.3.2.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding how the Sun's family of planets, satellites, and minor bodies originated and evolved. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7SSE1 Green | 8PS01 Green | 9PS1 Green | 10PS01 Green | PS-11-4 Green |
| Complete the MESSENGER Mercury Orbit Insertion. | 7SSE1 Green | 8PS02 Green | None | None | PS-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch at least three missions in support of this outcome. | | | | | 2.3.2.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the mission concept studies for the New Frontiers 3 mission. | None | None | None | 10PS04 Green | PS-11-3 Green |
| Complete the Juno Launch Readiness Review. | 7SSE3 White | 8PS03 Green | 9PS2 Green | 10PS02 Green | PS-11-6 Green |
| Complete the Gravity Recovery and Interior Laboratory (GRAIL) Pre-Ship Review. | None | None | 9PS3 Green | 10PS03 Green | PS-11-7 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.3.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding the processes that determine the history and future of habitability of environments on Mars and other solar system bodies. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7SSE6 Green | 8PS06 Green | 9PS8 Green | 10PS09 Green | PS-11-8 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, launch at least two missions in support of this outcome. | | | | | 2.3.3.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Mars Atmosphere and Volatile EvolutioN Mission (MAVEN) Confirmation Review. | None | None | None | 10PS08 Green | PS-11-10 Green |
| Complete the Mars Science Laboratory (MSL) Pre-Ship Review. | 7SSE5 Green | 8PS05 Green | 9PS4 Red | 10PS06 Yellow | PS-11-9 Green |

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.3.4.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding the origin and evolution of life on Earth and throughout the biosphere to determine if there is or ever has been life elsewhere in the universe. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7SSE4 Green | 8PS04 Green | 9PS5 Green | 10PS07 Green | PS-11-11 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.3.5.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in identifying and characterizing small bodies and the properties of planetary environments that pose a threat to terrestrial life or exploration or provide potentially exploitable resources. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7SSE8 Green | 8PS08 Green | 9PS9 Green | 10PS10 Green | PS-11-12 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Return data for selection of destinations in order to lower risk for human space exploration beyond low Earth orbit. | | | | | 2.3.5.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop an archive of high resolution images of the moon from the Lunar Reconnaissance Orbiter (LRO) necessary for human space exploration to determine potential landing sites. | None | None | 9AC16 Green | 10AC17 Green | PS-11-13 Green |
| | | | | | |
| **Uniform and Efficiency Measures** | | | | | |
| | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete all development projects within 110 percent of the cost and schedule baseline. | 7SSE10 Red | 8PS09 White | 9PS11 Red | 10PS15 White | PS-11-14 Green |
| Deliver at least 90 percent of scheduled operating hours for all operations and research facilities. | 7SSE11 Green | 8PS10 Green | 9PS12 Green | 10PS16 Green | PS-11-15 Green |
| Peer-review and competitively award at least 95 percent, by budget, of research projects. | 7SSE12 Green | 8PS11 Green | 9PS13 Green | 10PS13 Green | PS-11-16 Green |
| Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days. | 7SSE13 Red | 8PS12 Green | 9PS14 Green | 10PS14 Red | PS-11-17 Red |
| ***Why NASA rated Uniform and Efficiency Measure PS-11-17 Red:*** This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Planetary Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 76 days, approximately 35 percent of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. It is estimated that without the impact of the Continuing Resolution, the Planetary Science Division would have missed its target regardless. Other factors contributing to the missed target included staffing transitions in positions key to this process during FY 2011 (new Research & Analysis Lead and new program scientists). The involvement of these scientists in critical mission activities for multiple 2011 launches (Juno, GRAIL, MSL), as well as multiple FY 2011 Announcements of Opportunity also prevented improvement. (See page 173 for the Performance Improvement Plan.) | | | | | |

# Outcome 2.4

## Discover how the universe works, explore how it began and evolved, and search for Earth-like planets.

The Astrophysics theme seeks to understand the birth of the universe, the edges of space and time near black holes, and the dark energy that fills the entire universe. It is exploring the relationship between the smallest of sub-atomic particles and the vast expanse of the cosmos. Its missions reveal the diversity of planets and planetary system architectures in the Milky Way galaxy, pinpoint Earth-like, potentially life-supporting planets in other solar systems, and study stellar and planetary environments and what powers the most energetic galaxies. Astrophysics designs and launches space telescopes that work in conjunction with other ground and airborne telescopes to exploit the full range of the electromagnetic spectrum to view the broad diversity of the objects in the universe.



Astronomers using NASA's Wide-field Infrared Survey Explorer (WISE) have captured rare data of a flaring black hole, revealing new details about these powerful objects and their blazing jets. This artist's concept illustrates what the flaring black hole called GX 339-4 might look like. Infrared observations from WISE reveal the best information yet on the chaotic and extreme environments of this black hole's jets. GX 339-4 likely formed from a star that exploded. It is surrounded by an accretion disk (red) of material being pulled onto the black hole from a neighboring star (yellow orb). Some of this material is shot away in the form of jets (yellow flows above and below the disk). The region close in to the black hole glows brightly in infrared light. Read more about this story. (Credit: NASA)

NASA's Astrophysics missions have provided researchers with new ways of looking at the universe so that they can expand knowledge about cosmic origins and fundamental physics. The study of the universe benefits the Nation's scientific research community by focusing research and advanced technology developments on optics, sensors, guidance systems, and propulsion systems. Some of these new and improved technologies enable ground-breaking capabilities, which are then available to both the commercial and defense sectors.

Stunning images produced from Astrophysics' operating missions continue to inspire the public, revealing the beauty of the universe and the science behind those images. The striking images from these observatories also are educational tools to help spark student interest in science, technology, engineering, and mathematics and serve to prominently illustrate the role of the United States in scientific exploration. NASA provides the tools to translate the science for the classroom and other learning venues in ways that meet educator needs.

Astrophysics completed two major milestones during the fiscal year:

- NASA completed the System Integration Review (SIR) for the Nuclear Spectroscopic Telescope Array (NuSTAR) mission on January 28, 2011. The SIR evaluated the readiness of the project to start flight system assembly, test, and launch operations. NuSTAR will use high energy X-rays to search for black holes, map supernova explosions, and study the most extreme active galaxies.
- In September 2011, NASA's Program Management Council approved a rebaseline for the James Webb Space Telescope (JWST). This is the program's first major step in realigning cost and schedule commitments based on recent assessments of its planned science goals, technology readiness levels, progress to date, and risks. JWST, which entered development in July 2008, will use the infrared spectrum to observe the highly red-shifted early universe, where cool objects like protostars and protoplanetary disks emit strongly and dust obscures shorter wavelengths.

## Understanding black holes, dark energy, dark matter, and their relationship to the origin of the universe

### *Dark energy is accelerating the expansion of the universe*

A five-year survey of 200,000 galaxies using the Galaxy Evolution Explorer (GALEX) space telescope, stretching back seven billion years in cosmic time, has led to one of the best independent confirmations that dark energy is driving the universe apart at accelerating speeds. Astronomers think that the expansion of the universe is regulated by both the force of gravity, which acts to slow it down, and a mysterious dark energy, which pushes matter and space apart. In fact, dark energy is thought to be pushing the cosmos apart at faster and faster speeds, causing the universe's expansion to accelerate.

The findings offer new support for the favored theory of how dark energy works—as a constant force, uniformly affecting the universe and propelling its runaway expansion. Scientists think dark energy dominates the universe, making up about 74 percent of it. Dark matter, a slightly less mysterious substance, accounts for 22 percent. So-called normal matter, anything with atoms, or the stuff that makes up living creatures, planets and stars, is only about four percent of the cosmos. (Read more about GALEX's findings.)

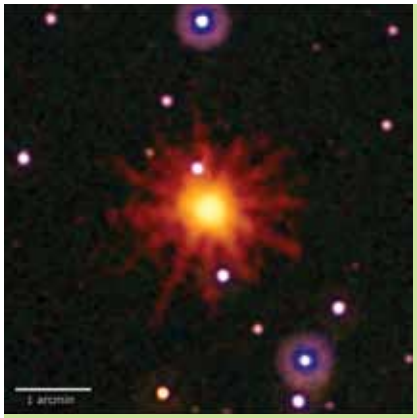
### *Telescopes join forces to observe unprecedented explosion*

NASA's Swift spacecraft, Hubble Space Telescope, and Chandra X-ray Observatory teamed up to study one of the most puzzling cosmic blasts yet observed. Astronomers discovered that it was a massive explosion that may be the death of a star torn apart by a black hole.

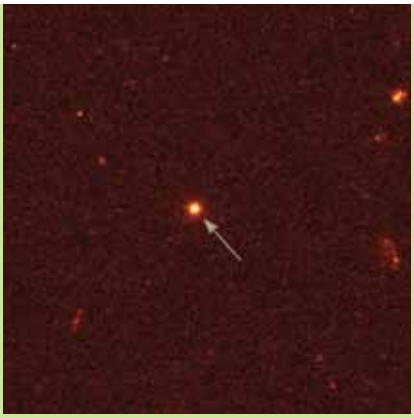
The explosive event was located in the center of a galaxy 3.8 billion light years away and lasted for over a week, with intermittent fading and brightening episodes. Nothing as bright, long-lasting, and variable has ever been observed from extragalactic sources. Gamma-ray bursts (bursts of gamma-ray photons, the most energetic form of light) usually mark the destruction of a massive star, but flaring emission from these events never lasts more than a few hours.

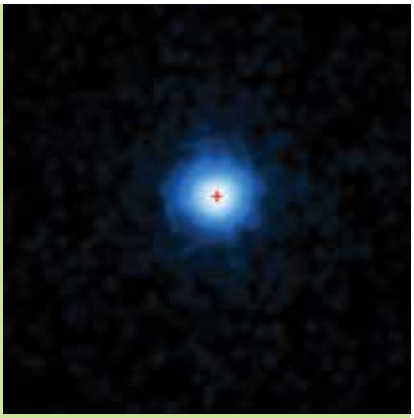
Although research is ongoing, astronomers suggest that the unusual blast arose when a star wandered too close to its galaxy's central black hole. Intense tidal forces tore the star apart, and the infalling gas continues to stream toward the hole. According to this model, the spinning black hole formed an out-flowing jet along its rotational axis. A powerful blast of X- and gamma rays is seen if this jet is pointed toward Earth.

Most galaxies, including the Milky Way, contain central black holes with millions of times the Sun's mass. Black holes in the largest galaxies can be a thousand times larger. The disrupted star probably succumbed to a black hole less massive than the Milky Way's. This discovery highlights the value of being able to observe events across multiple wavelengths—optical (Hubble), X-ray (Chandra), and Gamma-ray (Swift)—to pinpoint and better observe this dramatic explosion. (Read more about this story.)



(Credit: NASA/Swift/S. Immler)


(Credit: NASA/ESA/A. Fruchter, STScI)


(Credit: NASA/CXC/Warwick/A. Levan)

Images from Swift's Ultraviolet/Optical (white, purple) and X-ray telescopes (yellow, red) were combined to form the first view of the event, called GRB 110328A. The blast was detected only in X-rays, which were collected over more than three hours on March 28. The second view is a visible light image of the host galaxy (arrow) taken by Hubble on April 4. In the last image, taken by Chandra on April 4, the center of the X-ray source corresponds to the center of the host galaxy, marked with a red cross.

### *Fermi catches Earth thunderstorms hurling antimatter into space*

In late 2010, scientists using NASA's Fermi Gamma-ray Space Telescope detected beams of antimatter produced above thunderstorms on Earth, a phenomenon never seen before.

The scientists found that these antimatter particles, called positrons, were the result of a terrestrial gamma-ray flash (TGF), a brief burst produced inside thunderstorms known to be associated with lightning. They estimate that about 500 TGFs occur around the world daily, but most go undetected. The data collected by Fermi was the first direct evidence that thunderstorms make antimatter particle beams.

Since Fermi's launch in 2008, its Gamma-ray Burst Monitor (GBM) has detected over 130 TGFs. Such events are thought to originate in the strong electric fields near the tops of thunderstorms. When the field becomes strong enough, it can drive an upward avalanche of electrons that reach speeds nearly as fast as light. These high-energy electrons emit gamma rays when deflected by air molecules. Normally, it is the resulting broad spray of gamma rays that are detected as a TGF. However, the Fermi discovery suggests that some of the gamma rays spontaneously transform into electron and positron (antimatter) pairs that are accelerated in a tight beam clear out of the atmosphere into space. When antimatter striking the Fermi spacecraft collides with a particle of normal matter, both particles are immediately annihilated and transformed into gamma rays that are detected by the GBM. Fermi had to be in the right place at just the right time to be in a beam of antimatter. This suggests all TGFs probably emit electron/positron beams.

NASA's Fermi mission was designed to observe high-energy events in the cosmos, but the discovery that thunderstorms make antimatter is an excellent example of how basic science often leads to a better understanding of processes here on Earth. (Read more on this story.)

## Understanding how stars, planets, and galaxies formed and evolve

### *Hubble Space Telescope Contributes to Nobel Prize in Physics*

Observations made by NASA's Hubble Space Telescope of a special type of supernovae contributed to research on the expansion of the universe that was honored with the 2011 Nobel Prize in Physics.

Adam Riess, an astronomer at the Space Telescope Science Institute and Krieger–Eisenhower professor in physics and astronomy at the Johns Hopkins University in Baltimore, was a member of a team awarded the Nobel Prize in Physics by the Royal Swedish Academy of Sciences. The academy recognized him for leadership in the High-z Team's 1998 discovery that the expansion rate of the universe is accelerating, a phenomenon widely attributed to a mysterious, unexplained "dark energy" filling the universe. Critical parts of the work were done with NASA's Hubble Space Telescope.

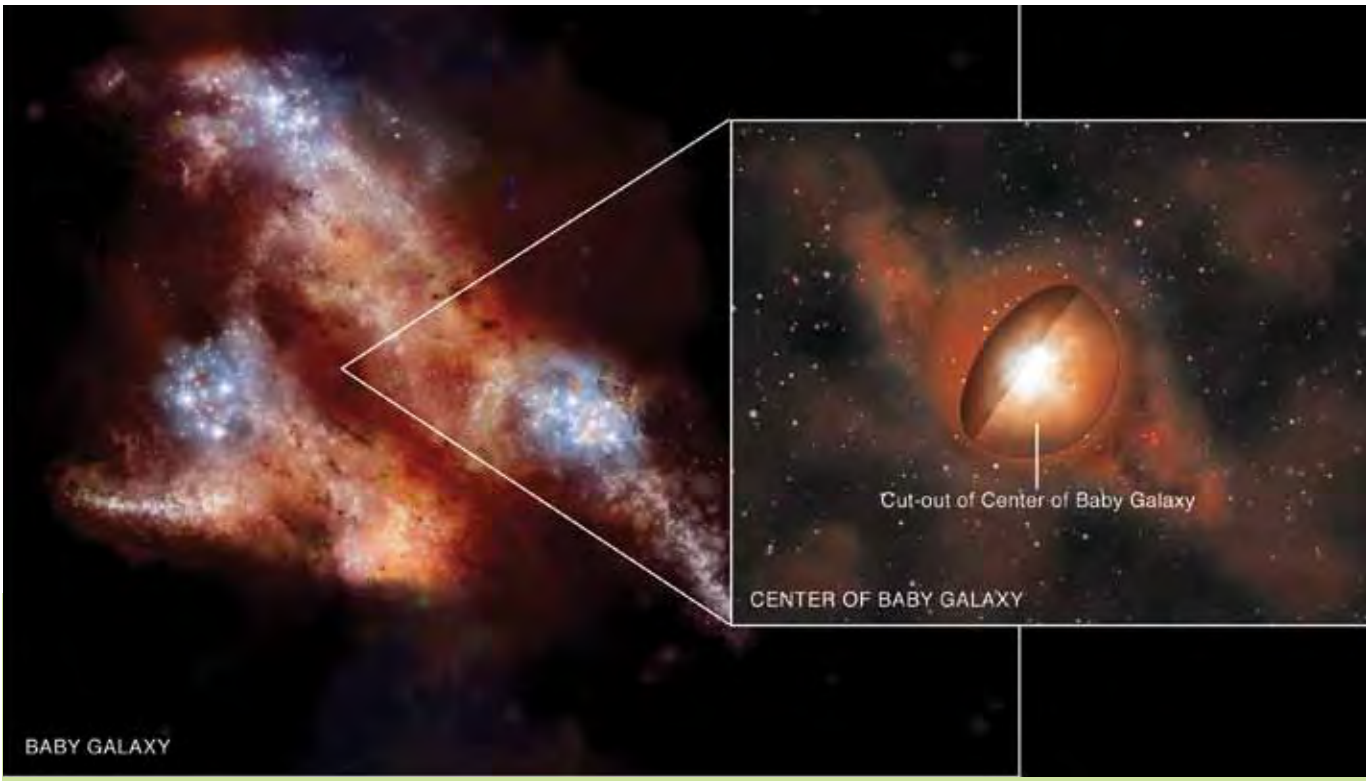
Riess shares the prize with Saul Perlmutter, an astrophysicist at the University of California at Berkeley and the Lawrence Berkeley National Laboratory, whose Supernova Cosmology Project team published similar results shortly after those published by Riess and High-z teammate Brian Schmidt of the Australian National University. Both teams shared the Peter Gruber Foundation's 2007 Cosmology Prize—a gold medal and $500,000—for the discovery of dark energy, which Science magazine called "The Breakthrough Discovery of the Year" in 1998.

Riess led the study for the High-z Supernova Search Team of highly difficult and precise measurements of objects that spanned seven billion light years that resulted in the 1998 discovery that many believe has changed astrophysics forever: an accelerated expansion of the universe propelled by dark energy. Hubble measured how the brightness of some of the most distant supernovae changed over time. This established that the universe is accelerating; the unknown agent responsible for the acceleration was dubbed "dark energy." The precision of Hubble measurements of the high redshift supernovae, which had been discovered from the ground, was crucial in the demonstration that distant supernovae were fainter than expected, and that the initial deceleration of the universe has astoundingly transformed into an accelerating expansion due to the effects of dark energy. (Read more about this story.)

### *NASA's Chandra and Hubble find massive black holes common in early universe*

Astronomers using the Hubble Space Telescope and the Chandra X-ray Observatory have found the first direct evidence that massive black holes are actively growing in the centers of the most distant galaxies known: galaxies forming within 950 million years of the Big Bang.

Astronomers have long known that most galaxies in the present-day universe (including the Milky Way) harbor massive black holes at their hearts, but the origin of these black holes has long remained a mystery. They also predicted that a population of young black holes existed in the early universe, but had not observed them until now. Data obtained by




The galaxy on the left appears distorted as the result of the many mergers that are responsible for its origin. The blue regions mark the areas of most active star formation. The core of the galaxy (shown in the inserted artist's impression) is embedded in dust and gas, which obscures the light produced by the rapidly growing black hole (shown also in the right panel). (Credit: NASA/CXC/M.Weiss)

Hubble and Chandra suggest that the baby black holes found in the early universe will eventually grow to become like the giant black holes seen in the current universe.

This discovery, which combines very deep observations from Chandra and Hubble, shows that very young black holes grow in tandem with their host galaxies and are so veiled by cold gas and dust within these galaxies that only the most energetic X-rays can escape. While Hubble can see the ultraviolet and optical light from the stars in these distant galaxies, only Chandra can detect the X-ray emission from their central black holes. By pointing Chandra at a single patch of sky for more than six weeks, the astronomers obtained the deepest X-ray image ever taken. They scrutinized the data for the detection of X-rays from about 200 of the most distant galaxies identified from Hubble observations of the same patch of sky. (Read more about these observations.)

### *WISE mission finds cool neighbors while generating an infrared legacy*

Scientists using data from NASA's WISE discovered the coldest class of star-like bodies, with temperatures as cool as the human body.

Astronomers hunted these dark orbs, termed Y dwarfs, for more than a decade without success. When viewed with a visible-light telescope, they are nearly impossible to see. WISE's infrared vision allowed the telescope to finally spot the faint glow of six Y dwarfs relatively close to the Sun, within a distance of about 40 light-years.

In February 2011, WISE completed its primary mission to map the sky, looking for neighbors that scientists did not know were there—the brightest galaxies and the coolest stars. Y dwarfs are the coldest members of the brown dwarf family. Brown dwarfs are sometimes referred to as "failed" stars. They are too low in mass to fuse atoms at their cores and thus don't burn with the fires that keep stars like the Sun shining steadily for billions of years. Instead, these objects cool and fade with time, until what little light they do emit is at infrared wavelengths.

Finding and characterizing the coolest brown dwarfs will set limits on star formation processes and determine the total amount of mass in stars, a key ingredient in modeling galaxy formation, and furthering understanding of very cold, planet-like atmospheres. The atmospheres of brown dwarfs are similar to those of gas-giant planets like Jupiter, but they are easier to observe because they are alone in space, away from the blinding light of a parent star. This new Y-class

would include brown dwarfs with atmospheres cool enough to contain water vapor capable of condensing to form clouds and water. (Read more about WISE's discovery of Y dwarfs.)

With the mapping of the sky recently completed in February 2011 and the first public data released on April 14, 2011 (http://wise2.ipac.caltech.edu/docs/release/prelim/index.html), WISE data mining has just begun (visit the data release site), but, already WISE has discovered over 100 brown dwarf stars. Along with the Y dwarfs, these include two of the lowest metallicity (metal deficient) blue compact dwarf galaxies. Very low metallicity galaxies are low redshift examples of the first generation of galaxies to form in the universe. It also has found some of the coolest brown dwarfs known.

### *SOFIA science observations take flight*

The Stratospheric Observatory for Infrared Astronomy (SOFIA) is nearing the end of the phase in which the SOFIA project team is developing the observatory and conducting early science flights in parallel. SOFIA is different from other missions contributing to this outcome. Instead of a spacecraft equipped with instruments, SOFIA is telescope installed in a specially modified 747 aircraft. In the next phase, SOFIA will be an operational mission. The project made significant progress in FY 2011 toward the next phase.

The project received its Reduced Vertical Separation Minimum certification, which allows SOFIA to now fly anywhere within the National Airspace System. Previously, it was restricted to a specific area for testing. The Basic Science 1 first competed science using the Faint Object Infrared Camera for SOFIA Telescope (FORCAST) started ahead of schedule on May 5. On June 23, SOFIA observed the dwarf planet Pluto as it passed in front of a distant star. This event, known as an "occultation," allowed scientific analysis of Pluto and its atmosphere by flying SOFIA at the right moment to an exact location where Pluto's shadow fell on Earth. A group of scientists and engineers from NASA's partners the German Aerospace Center, DLR, also were aboard to monitor the performance of the German-built telescope and Fast Diagnostic Camera (FDC). That camera has been used on previous flights to measure the stability of SOFIA and its optical systems. On this flight, the FDC provided supplemental observations of the Pluto occultation. (Read more about SOFIA's observations of Pluto.) In September, the aircraft received an avionics upgrade required for international flights so SOFIA could attend the annual German Aerospace Center open house in Cologne, Germany. (Read more about SOFIA's visit.)

## Finding planets beyond the solar system and measuring their properties

### *Kepler finds Earth-size planet candidates in habitable zone and a six planet system*

Since its launch in March 2009, NASA's Kepler mission has been seeking evidence of Earth-size planets in orbit around Sun-like stars as part of the Agency's effort to create a census of extra-solar planets and measure their properties and discovering a fascinating variety of extrasolar planets along the way. In February 2011, astronomers using Kepler found the first Earth-size planet candidates and the first candidates in the habitable zone, a region where liquid water could exist on a planet's surface and that could potentially host life. Kepler also found six confirmed planets orbiting a sun-like star. This is the largest group of transiting planets orbiting a single star ever discovered outside the solar system. Astronomers worldwide are working to confirm these planetary candidates as actual planets, rather than false positives, using ground-based observing and sophisticated data analysis with super computers.

Five of the potential planets are near Earth-size and orbit in the habitable zone of smaller, cooler stars than the Sun. The findings increase the number of planet candidates identified by Kepler to more than 1,235 in orbiting around 1,000 stars. Of these planets, 68 are approximately Earth-size, 288 are super-Earth-size, 662 are Neptune-size, 165 are the size of Jupiter, 19 are up to twice the size of Jupiter, 15 are more than twice the size of Jupiter, and 18 candidates show only one transit. (Read more on these discoveries.)

| **Outcome 2.4** | | | | | |
|---|---|---|---|---|---|
| Discover how the universe works, explore how it began and evolved, and search for Earth-like planets. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | **2.4.1.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | **7UNIV1 Green** | **8AS01 Green** | **9AS1 Green** | **10AS01 Green** | **AS-11-1 Green** |

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| By 2015, launch at least one mission in support of this outcome. | | | | | 2.4.1.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the Nuclear Spectroscopic Telescope Array (NuSTAR) Systems Integration Review. | None | None | None | 10AS02 Green | AS-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.4.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in understanding the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epochs to today. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7UNIV6 Green | 8AS06 Green | 9AS6 Green | 10AS09 Green | AS-11-3 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Design and assemble James Webb Space Telescope (JWST). | | | | | 2.4.2.2 Yellow |
| ***Why NASA rated Performance Goal 2.4.2.2 Yellow:*** The measure was placed in the FY 2012 Congressional Justification prior to the project's replan. Based on this, the baseline assumption for the measure was that the project was still operating under the original baseline. The new estimated baseline, which was approved late in the fiscal year, resulted in a 78% increase in the estimated lifecycle cost from the original baseline. The new estimated baseline has been endorsed by the NASA Administrator, all reporting required by Section 103 of the NASA Authorization Act of 2005 has been completed, and 95 percent of the FY 2011 planned activities were accomplished, indicating that it is likely to stay on track for the new estimated cost. Specifically, JWST achieved 19 of its 21 planned FY 2011 milestones on or ahead of schedule, one milestone was achieved one month late and one milestone was delayed due to design changes, and is on track to achieve its FY 2012 milestones. The one planned FY 2011 milestone that was achieved a month late and the one that has been delayed do not impact the critical path. (See page 130 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete new James Webb Space Telescope (JWST) mission re-baseline. | 7UNIV4 Green | 8AS04 Green | 9AS4 Green | 10AS06 Green | JWST-11-1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop and operate an airborne infrared astrophysics observatory. | | | | | 2.4.2.3 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Initiate the Stratospheric Observatory for Infrared Astronomy (SOFIA) science observations. | None | None | 9AS5 Yellow | 10AS07 Yellow | AS-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide national scientific capabilities through necessary skilled researchers and supporting knowledge base. | | | | | 2.4.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate planned progress in generating a census of extra-solar planets and measuring their properties. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review. | 7UNIV7 Green | 8AS07 Green | 9AS7 Green | 10AS10 Green | AS-11-5 Green |
| | | | | | |
| | | | | | |
| **Uniform and Efficiency Measures** | | | | | |
| | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete all development projects within 110 percent of the cost and schedule baseline. | 7UNIV9 Red | 8AS09 Yellow | 9AS12 Yellow | 10AS11 Green | AS-11-6 White |
| ***Why NASA rated APG AS-11-6 White:*** The metric indicates the final development costs, once a mission launches, but there were no planned launches for FY11 in Astrophysics. Hence the measure is not applicable to this fiscal year, and rated white. | | | | | |
| Deliver at least 90 percent of scheduled operating hours for all operations and research facilities. | 7UNIV10 Green | 8AS10 Green | 9AS13 Green | 10AS12 Green | AS-11-7 Green |
| Peer-review and competitively award at least 95 percent, by budget, of research projects. | 7UNIV11 Green | 8AS11 Green | 9AS14 Green | 10AS13 Green | AS-11-8 Green |
| Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days. | 7UNIV12 Green | 8AS12 Yellow | 9AS15 Green | 10AS14 Green | AS-11-9 Green |
| | | | | | |

# Strategic Goal 3

# Create the innovative new space technologies for our exploration, science, and economic future.

Creating the innovative new space technologies for America's exploration, science, and economic future requires development of capabilities that do not yet exist or are currently too immature and too high-risk to use for current missions. The inclusion of an untried technology poses risks to planned budgets and schedules due to the unknown and unpredictable issues that may arise. To responsibly accelerate technologies for enabling future missions, NASA, through the Office of the Chief Technologist and the Exploration Research and Development programs, has created a portfolio that spans the technology readiness level (TRL) spectrum and balances mission-focused and transformational technology investments. NASA prioritizes this portfolio using the Space Technology Grand Challenges, a set of important space-related problems that must be solved to efficiently and economically achieve NASA's missions, and the Space Technology Roadmap, an integrated set of 14 technology area roadmaps. This strategic goal addresses three categories of technology investments that will expand the NASA portfolio across the TRL spectrum.

The first set of technology investments focuses on fostering early-stage innovation in which a multitude of concept technologies are developed through a process of idea generation, research, innovation, and experimentation. NASA learns valuable lessons from these early-stage activities, even when some of the technologies do not work as intended. NASA's technology efforts through student grants, fellowships, and other opportunities to inspire innovators will help expand a future workforce and stimulate greater creativity in the Nation.

The second category focuses on taking the best low-TRL technologies—those studied under the first category—and determining which of these "disruptive" innovations and technologies are viable through further technology development, prototyping, experimentation, testing, and demonstrations. The goal of these technology activities is to validate whether or not substantial improvements in affordability, capability, or reliability are truly achievable for missions.

The third type of technology investment supports technology development targeting near-term unique spacecraft or mission needs. Through focused studies, dialogue, and development activities across NASA, as well as with academia and industry, these technology activities will provide improved future technologies that are closely aligned with known requirements. Building a comprehensive portfolio with both near- and long-term development activities will allow NASA to discover and advance high-payoff technologies that may fundamentally change the way humankind lives and explores.

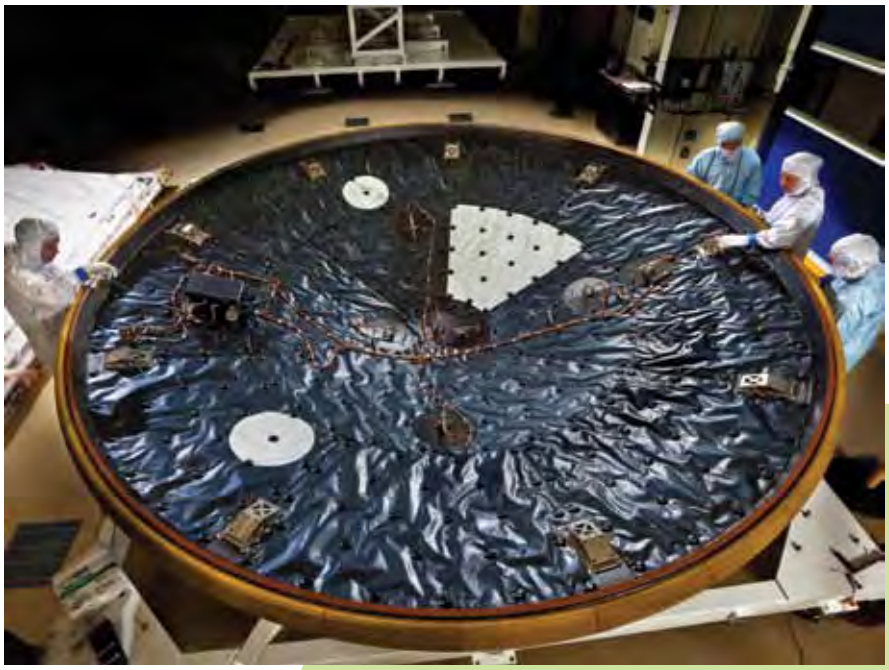
## Benefits

The Nation's economic competitiveness is due in large part to decades of investment in technology and innovation. Since NASA's inception, it has used innovative technology development programs to generate new science, exploration, and aeronautics capabilities. The Agency's innovations have enabled missions, contributed to other government agencies' needs, cultivated commercial aerospace enterprises, and fostered a technology-based U.S. economy. NASA will continue this tradition. Aggressive technology investments for exploration and discovery missions will create a vibrant commercial space sector through the establishment of new markets in future technologies. The Agency will transfer developed technologies, processes, discoveries, and knowledge to the commercial sector through various means including licenses, partnerships, and cooperative activities. These transferred technologies will be used to create products, services, cascading innovations, and other discoveries to fuel the Nation's economic engine and improve quality of life.

## Risk to Achieving Strategic Goal 3

**Implementation of a New Approach.** Over the last decade, NASA's technology development efforts have focused on incremental advances that enabled specific capabilities or missions. However, the increasing complexity and variety of challenges presented by current science, exploration, and aeronautics missions renders the incremental technology development model insufficient to meet mission needs. To enable NASA's long-term mission success requires accepting an aggressive technology development approach that has the potential to leap beyond the incremental successes and create new technologies that can dramatically improve Agency capabilities. With a willingness to dedicate funds to pure technology development, NASA is accepting a higher level of technology development risk related to unknown and unpredictable issues that may arise during the aggressive technology development process.

NASA is addressing this risk by developing a diverse portfolio spanning the TRL spectrum, including near-term, mission-focused technologies and longer-term, high-payoff transformational technologies that solve difficult space-related problems and together ensure mission success. Through implementation of such a sustainable, strategic approach toward technology development, NASA will address the immediate needs of its missions, foster an innovative culture within the Agency to meet long-term strategic goals, and contribute to the Nation's technological competitiveness.



The Mars Entry, Descent and Landing Instrument (MEDLI) is visible at the middle left of the aeroshell/heatshield for the Mars Science Laboratory (MSL). Built by the Langley Research Center, MEDLI is actually made up of two kinds of instruments (with seven sensors of each kind) that are installed in 14 places on the spacecraft's heat shield. The MEDLI instrumentation will measure heat shield temperatures and atmospheric pressures during the spacecraft's high-speed, extremely hot entry into the Martian atmosphere. The data will help engineers design future systems for Mars entry that are safer, more reliable, and lighter weight. (Credit: Lockheed Martin)

# Outcome 3.1

## Sponsor early stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.

The Office of the Chief Technologist (OCT) considers early-stage innovation—low technology readiness level (TRL) technology—to be the foundation of the development process. Investment in low-TRL technology increases knowledge and capabilities in response to new questions and requirements, and it stimulates creative new solutions to the challenges faced by NASA and the larger aerospace community.

Investments in low-TRL projects, through partnerships with the public and private sectors, have historically benefited the Nation on a broad basis, generating new industries and spin-off applications and providing a cadre of new technology-savvy innovators to fuel the Nation's high-tech economy.

Below are some of activities pursued and achievements made during FY 2011 for this outcome.

### Exploring revolutionary concepts

#### *Renewed NIAC exceeds target, spurs imaginative technologies*

In 2011, NASA Innovative Advanced Concepts, or NIAC, selected 30 proposals for funding, exceeding its target of 10 proposals by 300 percent. OCT chose the advanced concepts for study based on their potential to transform NASA's future space missions, enable new capabilities, or significantly alter current approaches to launching, building, and operating space systems.

The original NIAC program ran from 1998 to 2007. With NASA's renewed emphasis on space technology development, NASA re-established NIAC in 2011 to fund early studies of visionary concepts with long term, challenging development goals. The new NIAC office allows proposal opportunities to be open to principal investigators or teams both internal and external to NASA.

These first NIAC proposals included a broad range of imaginative and creative ideas, such as changing the course of dangerous orbital debris, developing a spacesuit that uses flywheels to stabilize and assist astronauts as they work in microgravity, using three dimensional printing to create a planetary outpost, and developing multiple innovative propulsion and power concepts needed for future space mission operations. Each award received approximately $100,000 for one year to advance the innovative space technology concept and to help NASA meet future mission requirements. For a complete list of the selected proposals, and more information about the program, visit http://www.nasa.gov/offices/oct/early_stage_innovation/niac/2011_phase1_selections.html.

### Tapping non-traditional sources through Centennial Challenges

The Centennial Challenge Program provides cash prize incentives to non-traditional sources for innovations of interest and value to NASA and the Nation by conducting prize purse competitions to achieve challenging technology performance targets. NASA provides the prize purse while non-profit entities manage the competitions at no cost to NASA. These competitions expand the pool of innovators and stimulate effort from non-traditional sources to find solutions to technical challenges that support NASA's missions in aeronautics and space.

NASA and its partners have been conducting Centennial Challenges for a variety of technologies and capabilities since 2006. In 2011, there were two Centennial Challenge competitions, summarized below.

#### *NASA awards historic Green Aviation prize*

NASA has awarded the largest prize in aviation history—a Centennial Challenge created to inspire the development of more fuel-efficient aircraft and spark the start of a new electric airplane industry. The technologies demonstrated by the Comparative Aircraft Flight Efficiency (CAFÉ) Foundation Green Flight Challenge, sponsored by Google, may end up in general aviation aircraft, spawning new jobs and new industries for the 21st century.

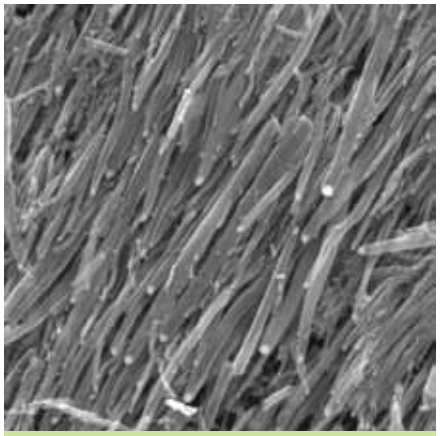
The Green Flight Centennial Challenge succeeded in advancing technologies in aircraft fuel efficiency and reduced emissions with cleaner renewable fuels and electric aircraft. Fourteen teams originally registered for the competition. Three teams successfully met all requirements and competed in September 2011 in the skies over the Charles M. Schulz Sonoma County Airport in Santa Rosa, California. Following remarks by NASA Acting Chief Technologist Joseph Parrish and CAFÉ Foundation President Brien Seeley, NASA awarded the first place prize of $1.35 million to Pipistrel-USA.com of State College, Pennsylvania, and second place prize of $120,000 to eGenius of Ramona, California.

The Pipistrel-USA Taurus G4 aircraft prepares to takeoff for the miles per gallon flight during the 2011 Green Flight Challenge on September 27, 2011. (Credit: NASA/B. Ingalls)

The winning aircraft had to fly 200 miles in less than two hours and use less than one gallon of fuel per occupant, or the equivalent in electricity. The first and second place teams, which were both electric-powered, achieved about twice the fuel efficiency requirement of the competition, meaning they each flew 200 miles using a little over a half-gallon of fuel equivalent per passenger.

### *Strong Tether prize remains elusive*

NASA conducted the Strong Tether Challenge on August 12 as part of the 2011 Space Elevator Conference. The Space Elevator Conference, sponsored by Microsoft, the Leeward Space Foundation, and the International Space Elevator Consortium has hosted the tether competition for five years and for this, the fifth year in a row, there was not a winner. Although no competitor has been able to claim the Centennial Challenge prize, over the years, the competitors have developed increasingly stronger tethers as they discovered new and innovative methods for fabricating tethers with carbon nanotube technology.



Carbon nanotubes, shown here, are long, hollow tubes formed from one-atom thick sheets of carbon. Individual nanotubes naturally align themselves into ropes. (Credit: NASA)

The Strong Tether Challenge focuses material science technologies to create long, very strong cables (known as tethers) with exceptionally high strength-to-weight ratio. Such tethers will enable advances in aerospace capabilities, including reduction in rocket mass, habitable space structures, tether-based propulsion systems, solar sails, and even space elevators. Dramatically stronger and lighter materials are also revolutionizing the engineering of down-to-earth structures like aircraft bodies, sporting good equipment, and even structures of bridges and buildings. This year, two competitors unsuccessfully tried for the Tether challenge's $2 million prize purse.

## Maintaining a culture of innovation

### *NASA awards Center Innovation Funds*

In 2011, NASA distributed funds among its 10 Centers to support more than 82 low-TRL, innovative technology initiatives that leverage Center talent and capability.

The objective of the Center Innovation Fund is to stimulate and encourage creativity and innovation within the NASA Centers by funding activities that fall within the scope of NASA Space Technology or address a significant national need. Through the Center chief technologist, each Center conducted a competition to select projects. NASA scientists and engineers lead the projects, which are scored annually by OCT to guide follow-on funding distribution.

## Working with Small Business

The Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs as implemented by NASA provide an opportunity for small, high technology companies and research institutions to participate in NASA's research and development efforts in key technology areas. These programs have produced innovative technologies for NASA missions, in accordance with NASA's Strategic Plan, as well as commercial products for the betterment of humankind since the effort's beginning in 1984.

SBIR contracts with Langley Research Center and satellite data from the Stennis Space Center allowed Colorado-based Terra Metrics, Inc., to develop a satellite imagery and terrain data product line that features in Google Earth, as well as a three-dimensional, terrain-rendering engine that enables synthetic vision solutions for aircraft, enhancing pilot's situational awareness during flight. (Credit: Terra Metrics)

### *Awards help small business partners develop technologies*

OCT exceeded its 2011 goal of infusing 24 percent of SBIR/STTR technology programs funded from fiscal years 2004 through 2008 into NASA projects by achieving 28 percent. During that time period, NASA initiated 766 projects, of which 218 developed technologies that were:

- Infused into NASA programs;
- Adopted for use in future missions;
- Chosen for further development after emerging from SBIR/STTR Phase I and Phase II; or
- Were otherwise meaningfully participating in NASA's projects and activities.

The purpose of Phase I is to determine the scientific, technical, and commercial merit and the feasibility of the proposed innovation (only Phase I contractors are eligible for Phase II funding agreements). Successful completion of Phase I objectives is a prerequisite for consideration of a Phase II award. The purpose of Phase II is the development, demonstration, and delivery of the innovation.

During 2011, NASA selected 451 proposals from small business firms for Phase I awards and 213 proposals for Phase II awards. In addition, NASA selected 45 STTRs for Phase I awards and 27 for Phase II awards. NASA is executing Phase IIE options with 24 firms that have validated non-SBIR matching funds. Phase IIE options are intended to encourage the transition of Phase II contracts into Phase II opportunities by providing a cost share extension of Phase II contracts. Under this option, NASA will match non-SBIR/non-STTR investment from a NASA project, NASA contract, or third commercial investor. Maximum value and period of performance for Phase I and Phase II contracts and more information may be found at http://sbir.gsfc.nasa.gov/SBIR/SBIR.html.

During FY 2011, award amounts have been increased: Phase I awards from $100,000 to $125,000, Phase II awards from $600,000 to $750,000, and the Phase IIE option from $150,000 to $250,000 with non-SBIR/STTR matching funds. This increase is within the March 2010 Small Business Administration authorization of a new threshold for SBIR awards. The authorization also introduced subtopics with a Technology Available (TAV) designation, which addresses the objective of using NASA intellectual property as a basis for the proposed innovation. Based on NASA's Office of Inspector General recommendations, NASA has increased internal controls to help prevent waste, fraud, and abuse in the program. Additionally, NASA leveraged the Recovery Act investment, with its unprecedented accountability and transparency, to pilot these controls before moving them mainstream, in this year. These changes included additional training for contracting officer's technical representatives (the civil servants who serve as liaisons between the government and the contractors and are responsible for authorizing contract expenditures) and proposal reviewers, virtual site visits for first time Phase II awardees, and increased documentation in contract files.

## Accelerating Space Technology research

### *Inaugural class of NASA Space Technology Research Fellows Selected*

Space Technology Research Opportunities (ESI-STRO), which competitively select high risk, high payoff groundbreaking research in advanced space technology. As part of NASA's strategy to develop the technological foundation for

its future science and exploration missions, the Agency seeks graduate students who will be dedicated to performing innovative space technology research while building the skills necessary to become future technological leaders.

FY 2011 featured the selection and award of the inaugural class of NASA Space Technology Research Fellows. The Space Technology Research Grants Program awarded 80 graduate students fellowships to pursue master's or doctoral degrees in relevant space technology disciplines at their respective institutions. Fellows will perform innovative space technology research while building the skills necessary to become future technological leaders.

These and future fellows will provide the Nation with a pipeline of highly skilled engineers and technologists to improve U.S. competitiveness. The fellows will perform graduate student research on their respective campuses and at NASA Centers and nonprofit U.S. research and development laboratories. For a list of fellowship recipients, their research institutions and their research topics, please visit http://www.nasa.gov/offices/oct/early_stage_innovation/grants/2011_inaugural_class.html.

## Outcome 3.1

Sponsor early-stage innovation in space technologies in order to improve the future capabilities of NASA, other government agencies, and the aerospace industry.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Explore revolutionary aerospace concepts, with an initial research phase for preliminary assessment of a broad range of ideas, and a second phase for further development of the most promising concepts. | | | | | 3.1.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Initiate 10 Phase I research efforts to explore revolutionary aerospace ideas. | None | None | None | None | ST-11-1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide cash prize incentives to non-traditional sources for innovations of interest and value to NASA and the Nation. | | | | | 3.1.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Conduct at least two Centennial Challenge competitions. | 7ESRT3 Green | 8IPP06 Green | None | None | ST-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Establish and maintain a culture of innovation at each of the 10 NASA Centers through the development of new Center ideas and technologies. | | | | | 3.1.1.3 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Twenty innovative projects will be initiated across the NASA Centers. | None | None | None | None | ST-11-3 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Increase the proportion of Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) technologies successfully infused into NASA programs/projects. | | | | | 3.1.1.4 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| At least 24 percent of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase II technology projects awarded between 2004-2008 will be infused into NASA programs and projects. | None | None | None | 10IPP07 Green | ST-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Increase the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase III contracts initiated or expanded. | | | | | 3.1.1.5 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| At least 40 of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) technologies will be advanced to Phase III (received non-SBIR/STTR funding). | None | None | None | 10IPP04 Green | ST-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Accelerate the development of push technologies to support the future space, science and exploration needs of NASA, other government agencies, and the commercial space sector. | | | | | 3.1.1.6 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Select 100 NASA space technology research activities. | None | None | None | None | ST-11-6 Green |

# Outcome 3.2

## Infuse game changing and crosscutting technologies throughout the Nation's space enterprise, to transform the Nation's space mission capabilities.

For a sustainable set of affordable programs that achieve longer-term goals, NASA requires a faster, more aggressive strategy for creating and applying new technologies. Without a robust effort that matures technologies and establishes their feasibility, the ideas and transformational concepts developed at a low technology readiness level (TRL) may not materialize into benefits for future NASA missions or the Nation's economy. The Office of the Chief Technologist (OCT) bridges the gap between idea formulation and mission infusion to deliver improvements to future missions. OCT focuses on maturing mid-TRL technologies and proving the feasibility of advanced space concepts and technologies that may lead to entirely new approaches to space system design and operations, exploration, and scientific research. Through significant modeling, analysis, ground-based testing, and laboratory experimentation, OCT will mature technologies in preparation for potential system-level flight demonstrations within NASA itself or by other government agencies. Executing these challenging laboratory and space flight demonstrations requires creating technology projects with well-defined milestones and schedules, developing facilities, laboratories, and flight test opportunities, fabricating materials, hardware, and software, developing and integrating technologies, and conducting demonstrations.

### *Building Game-Changing Technology*

NASA's Game Changing Technology (GCT) investments focus on maturing advanced space technologies that may lead to entirely new approaches for the Agency's future space missions and solutions to significant national needs.

In 2011, GCT released a Broad Agency Announcement for Unique and Innovative Technologies to enable revolutionary improvements to the efficiency and effectiveness of the Nation's space capability and made selections for three awards. The GCT theme funded technology development work for a ground composite cryotank structural demonstration, a hypersonic inflatable aerocapture demonstration, and a low-density supersonic decelerator. Through significant ground-based testing and/or laboratory experimentation, GCT matures technologies in preparation for potential system level flight demonstration within OCT Crosscutting Capability Demonstrations, within other NASA mission directorates, or by other government agencies. GCT also developed 10 pre-competitive concept packages in areas including tether propulsion, avionics, power beaming, and horizontal launch.

### *NASA selects program's first demonstration missions*

Technology Demonstration Missions (TDM) demonstrate and infuse crosscutting, game changing space technologies. OCT released TDM's inaugural Broad Agency Announcement on March 1, and received 47 space technology demonstration proposals by June 24. On August 22, OCT selected three demonstration missions: a deep space atomic clock for space navigation and timing, a mission-capable solar sailing system that would not require a propellant, and a demonstration of next-generation optical communications. OCT selected these crosscutting flight demonstrations because of their potential to provide tangible, near-term products and infuse high-impact capabilities into NASA's future space missions.

The three funded space technology demonstration missions kicked off in September 2011. The projects incorporate all elements of the flight test demonstration, including test planning, development of flight hardware, launch, ground operations, and post-testing assessment and reporting. The atomic clock and solar sail will be ready for flight in three years. The optical communications team anticipates it will take four years to mature their technology for flight. Each of the selected teams also will receive funding from partners who plan on using the technologies as part of future space missions. The Space Technology Program is cost

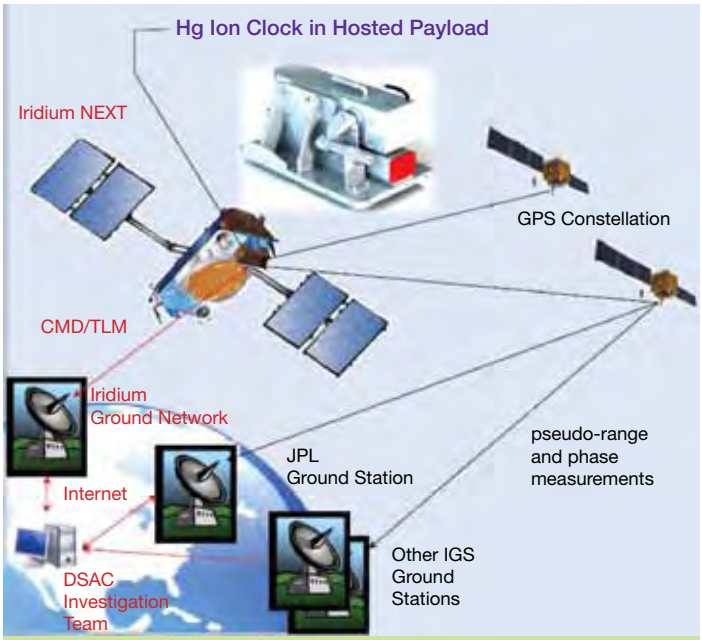
A four quadrant, 65-foot (20-meter) solar sail system is fully deployed for testing in 2005. The design was another solar sail tested by L'Garde, Inc., the company that will be conducting the solar sail demonstration mission for TDM. (Credit: NASA)

sharing with the National Oceanic and Atmospheric Administration (NOAA) on the solar sail demonstration and with other programs in NASA's Human Exploration and Operations (HEO) Mission Directorate on the space communications and navigation demonstrations. (Find out more about the selected space technology demonstration missions.)

By investing in high payoff, disruptive technology (or truly transformational technology) that American industry does not have in hand today, like those selected for the first demonstration missions, NASA matures the technology required for its future missions while providing the capabilities and lowering the cost of space endeavors for other government agencies and industry.

### *New program provides flight opportunities*

In FY 2011, the Flight Opportunities Program competitively selected seven commercial space companies, six of which are small businesses, to provide commercial suborbital flight payload integration services. Through an open call to researchers from NASA, other government agencies, industry, and academia for payloads seeking flights, the program selected 23 payloads: 15 seeking parabolic flights, five seeking suborbital flights, and three seeking both. The program flew 14 payloads in reduced gravity environment as part of flight campaigns held in July, August, and September 2011.




Led by the Jet Propulsion Laboratory, the Deep Space Atomic Clock (DSAC) team will collaborate with NASA's Space Communications and Navigation office and the Office of the Chief Technologist to create an atomic clock for deep space navigation and radio science. Among the potential benefits would be improving clock stability of the next global positioning system (GPS) by 100 times. (Credit: NASA)

Researchers and students from at least 10 universities, four NASA Centers, and two industry payload providers flew their technology payloads in near-zero, lunar, and Mars gravity environments. The suborbital flight providers have resolved a number of technical issues, and have flown several tethered flights that would lead to eventual successful flights. The program flew technology payloads from the Federal Aviation Administration and NASA on a successful commercial suborbital test flight.

The Flight Opportunities Program combines the FY 2010 Facilitated Access to the Space environment for Technology (FAST) and Commercial Reusable Suborbital Research (CRuSR) efforts previously managed by the Innovative Partnership Program. The program provides flight opportunities for technology development, scientific research, and education efforts in reduced-gravity environments, brief periods of weightlessness, and high-altitude atmospheric research. These flights are expected to reduce risks associated with emerging technologies and procedures and of overall space operations in future missions by demonstrating application in a relevant environment. The Flight Opportunities Program also helps foster the development of the commercial reusable suborbital transportation industry, an important step in the longer-term path that envisions suborbital reusable launch vehicles evolving to provide the Nation with much lower-cost, more frequent, and more reliable access to orbital space.

## Outcome 3.2

Infuse game changing and crosscutting technologies throughout the Nation's space enterprise to transform the Nation's space mission capabilities.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Transition developed game changing technologies to the technology demonstration programs or directly to Mission Directorates for mission insertion. | | | | | 3.2.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Initiate ten conceptual studies to define potential game changing development projects. | None | None | None | None | ST-11-7 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Mature technologies that enable small satellites to provide game changing capabilities for the government and commercial space sectors. | | | | | 3.2.2.1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Demonstrate small satellite capabilities with game changing and crosscutting potential for the government and commercial space sectors. | | | | | 3.2.3.1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Infuse game changing and crosscutting technologies into future NASA missions through flight or relevant environment demonstrations. | | | | | 3.2.4.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Select two candidate system level technologies that will provide new capabilities for future missions. | None | None | None | None | ST-11-10 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Perform sub-orbital, simulated zero-gravity and other space analog flight opportunities to develop and demonstrate emerging ideas and technologies. | | | | | 3.2.5.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Select and fly technology payloads from NASA, other government agencies, industry, and academia using flight services procured from at least three commercial reusable suborbital and parabolic platform providers. | None | None | None | None | ST-11-11 Green |

# Outcome 3.3

## Develop and demonstrate the critical technologies that will make NASA's exploration, science, and discovery missions more affordable and more capable.

The purpose of mission-driven technology development is to meet unique near-term mission needs within technical, cost, and schedule goals. NASA is prioritizing the desired set of future technologies that will offer the most synergies and advancement of mission capabilities. The Agency is enabling advances and improved performance by furthering existing evolutionary technologies, as well as developing revolutionary new technologies. It also is balancing potential technology benefits with specific mission risks to establish the appropriate time frame to infuse each emerging technology.

### *NASA develops mission driven technologies to meet unique near-term mission needs*

NASA's Exploration Technology Development Program (ETDP) developed and demonstrated a number of technologies designed to enable science and exploration missions in FY 2011.

Early in the fiscal year, the Radiation Assessment Detector (RAD) was delivered and integrated onto the NASA Science Mission Directorate's Mars Science Laboratory rover, *Curiosity*. RAD will aid future human missions to Mars by providing information about the radiation environment on Mars and on the way to Mars.

RAD, shown prior to its installation, will monitor high-energy atomic and subatomic particles from the Sun, distant supernovae, and other natural sources. These particles are natural radiation that could be harmful to astronauts on a Mars mission. This image shows the flight hardware with a red "remove before flight" cover on top of the instrument's telescope. (Credit: NASA/JPL-Caltech/SwRI)

In February, ETDP launched the human-like Robonaut 2 hardware to the International Space Station (ISS) on STS-133. The 330-pound Robonaut 2 consists of a head and a torso with two arms and two dexterous hands. Engineers are monitoring how it operates in near microgravity, with the objective of using it as a robotic assistant that can work alongside the crew. Currently Robonaut is confined to operations in the ISS' Destiny laboratory. However, future enhancements and modifications may allow it to move more freely around the interior or outside the complex.

### *Studying future technologies*

In support of future technology activities, NASA issued Broad Agency Announcements for Cryogenic Propellant Storage and Transfer and Solar Electric Propulsion mission concept studies in May and June. NASA selected four companies in early August to perform Cryogenic Propellant Storage and Transfer mission concept studies. The concept studies will test and validate key capabilities and technologies required for future exploration elements such as large cryogenic propulsion stages and propellant depots. Solar Electric Propulsion mission concept studies will be selected in FY 2012.

## Outcome 3.3

Develop and demonstrate the critical technologies that will make NASA's exploration, science, and discovery missions more affordable and more capable.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Demonstrate robotic technologies that support in-space operations, scientific discovery, and work as assistants with the crew. | | | | | 3.3.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Launch Robonaut 2 to the ISS and demonstrate teleoperation from the ground. | None | None | None | None | ERD-11-7 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop advanced spacesuits to improve the ability of astronauts to conduct Extra-Vehicular Activity (EVA) operations in space including assembly and service of in-space systems and exploration of surfaces of the Moon, Mars, near-Earth objects (NEOs), and other small bodies. | | | | | 3.3.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Test breadboard Extra-Vehicular Activity (EVA) Portable Life Support System (PLSS) technologies to enable advanced spacesuits for human deep space exploration. | None | None | 9AC14 Green<br>9AC6 Green | None | ERD-11-8 Green |
| | | 8CS06 Yellow | 9CS5 Red | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop technologies and mission concepts for demonstrating in-space cryogenic propellant storage and transfer making exploration and science missions more affordable and capable. | | | | | 3.3.2.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop and test Liquid Acquisition Devices (LADs) and mass-gauging to support future Cryogenic Propellant Storage And Transfer (CRYOSTAT) missions. | None | None | None | None | ST-11-12 Green |

# Outcome 3.4

## Facilitate the transfer of NASA technology and engage in partnerships with other government Agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.

While technology and innovation are critical to accomplishing NASA's missions, it also benefits the U.S. economy through transfer of new technologies for other applications. NASA makes a determined effort to transfer technologies outside of the Agency and to develop technology partnerships. NASA's technology investments support advancement in key research areas, fuel rapid improvements in mission capabilities, foster a robust industrial base, improve the Nation's competitive position in the international marketplace, enable new industries, improve quality of life, and contribute to economic growth.

NASA seeks partnerships and cooperative activities with the emerging commercial space sector. Three key themes underscore this effort: considering the private sector as an investment partner and sharing the cost of developing a capability; purchasing services rather than hardware when possible; and fostering the creation of broader opportunities for innovation. Pursuing these partnership themes brings direct value to NASA's current and future missions, advances the interests of the partners, and encourages additional commercial space development. In addition to partnership strategies, NASA seeks to transfer its technologies directly to other government agencies, the national aerospace industry, and the broader U.S. commercial sector. NASA-spurred advances in energy, communication, health, materials science, and other fields generate spinoff applications that benefit the Nation. The Agency has established a core team at each Center charged with technology transfer, licensing, and new partnership development, and these teams work closely with scientists and engineers to match NASA technologies with the needs of external organizations.

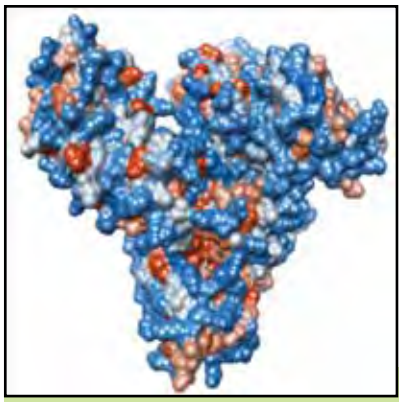
Guided by the Office of Chief Technologist (OCT), the Innovative Partnerships Office has a dual role: to seek partnerships that can leverage technologies, expertise, and capabilities to advance NASA's missions and to provide access to NASA resources including intellectual property that will benefit the United States through economic growth and improved quality of life. To achieve these two complementary objectives, NASA technology transfer professionals work closely with NASA Center scientists, engineers, and software developers to foster commercial application of NASA's wide spectrum of research and technology development. As noted in the annual NASA *Spinoff* publications (http://www.sti.nasa.gov/tto/), partnerships forged between NASA and others with shared vision and objectives have saved hundreds of lives, created thousands of jobs, provided millions of dollars in cost avoidance, and generated millions of dollars in revenue. More about the Agency's technology transfer activities also is available on NASA's Open Government Initiative site at http://www.nasa.gov/open/plan/technology-transfer.html.

In FY 2011, NASA executed over 292 Space Act Agreements, signed 562 Software Use Agreements, filed 101 Patent applications, signed 31 invention licenses, and made 1,335 invention disclosures. These measures are tracked in the NASA Technology Transfer System (NTTS).

### Documenting successful technology transfers

NASA missions have given the world extraordinary new knowledge about our planet and the universe. Sometimes, they have even challenged what we think we know. Along the way, the technologies and capabilities NASA has developed to enable those missions have transformed life on Earth.

Since 1976, NASA has provided evidence of its technology transfer successes using its annual *Spinoff* publication to document examples of private sector companies developing products and services derived in part or in full from NASA technologies and other resources. In *Spinoff*, NASA highlights some of the most recent of these societal benefits generated by aeronautics and space missions. The outcomes of these partnerships have reached throughout the economy and around the globe, as the resulting commercial products contributed to the development of services and technologies in the fields of health and medicine, transportation, public safety, consumer goods, environmental resources, computer technology, and industry.



NASA experiments with protein crystal growth in space led to the first-ever synthetic albumin for drug delivery and a unique line of skin-care products. (Credit: New Century Pharmaceuticals)

This year's issue of *Spinoff* featured 43 stories of successful NASA technology transfer (including 21 articles about Small Business Innovative Research (SBIR)-developed technologies). This year's publication spans a remarkable field of innovations, including the following stories:

### *Bioreactors drive advances in tissue engineering*

Johnson Space Center innovators created a rotating wall bioreactor that mimics microgravity conditions, allowing for healthier, more natural-forming cell cultures. Licensed to Synthecon, Inc., of Houston, the technology now enables drug development and medical research into treatment for conditions such as diabetes and cancer.

### *Protein innovations advance drug treatments, skin care*

While at Marshall Space Flight Center, Dan Carter and colleagues mapped the atomic structure of albumin, an important blood protein, for the first time. Carter formed New Century Pharmaceuticals of Huntsville, Alabama, to build on this achievement, resulting in new skin care products and platforms for cancer treatment.

### *High-pressure systems suppress fires in seconds*

By applying principles from a new kind of rocket engine—developed by Orbital Technologies Corporation of Madison, Wisconsin, under SBIR contracts with Marshall Space Flight Center—to fire hose nozzles, company subsidiary HMA Fire improved the performance of its ultra- high pressure fire suppression systems, which extinguish many fires in significantly less time and using less water than traditional systems.

Work in higher-powered, lower-cost, versatile, and even reusable vortex hybrid rocket engines that effectively manage ultra-high pressure flows resulted in a new low volume, high-pressure fire suppression system. In one test, this system extinguished a standard fire in 80 percent less time and with six percent less water than standard methods. (Credit: Orbital Technologies Corporation)

### *Retrofits convert gas vehicles into hybrids*

Working with Glenn Research Center through the NASA Illinois Commercialization Center, NetGain Technologies LLC of Lockport, Illinois, developed a retrofit system for converting gas-powered vehicles to gas-electric hybrids. The partnership also resulted in a line of electric motors for vehicles marketed by NetGain Motors, Inc., the production of which supports over 100 jobs at the company's manufacturing facility.

### *Coating processes boost performance of solar cells*

While working on Glenn Research Center-funded projects, scientist Maria Faur invented a process for coating solar cells that both significantly reduces production costs and increases cell efficiency. Faur's company, North Olmstead, Ohio-based SPECMAT, Inc., has licensed the process to a company that believes it could revolutionize the solar energy industry.

### *Controller chips preserve microprocessor function*

To develop controller technology for a variety of missions, Marshall Space Flight Center partnered with a San Diego-based company, Space Micro, Inc., through the SBIR program. Today, the technology is embedded in the company's entire series of high-performance, radiation-hardened computers for space. The company has expanded from four employees at the beginning of its NASA partnership to 43 today, growing from a $1 million to a $8 million company.

These benefits and myriad additional benefits are visible in our everyday lives in a wide array of applications, and the serve as a testament to NASA's ingenuity and success in transferring space technologies back down to Earth.

## Managing NASA's technology portfolio

### *National Academies evaluating NASA's space technology roadmaps*

In FY 2011, NASA developed a set of 14 space technology roadmaps and engaged the National Academies to review the roadmaps and evaluate the balance of near-term mission-focused technology and longer-term transformational technology.

The Aeronautics and Space Engineering Board (ASEB) released an interim report on their review of NASA's draft Space Technology Roadmaps. In early 2012, the steering committee will conclude with a final report, which will provide specific guidance on how technology development funded by the Space Technology program can enhance the Agency's space science and exploration capabilities. For more information on the evaluation, visit ASEB's site at http://sites.nationalacademies.org/DEPS/ASEB/DEPS_059552.

### *Tracking NASA's technologies*

NASA must capture the investments in space technology and make them available for strategic coordination internally and accessible to industry, academia, and international partners to further cultivate technological innovation and entrepreneurship in the commercial space sector. Consistent with this objective, NASA is developing a Technology Portfolio Tracking System with the capability to document, coordinate, and prioritize Agency-level technology strategic investments to ensure a balanced portfolio of both near-term NASA mission technologies and longer-term transformational technologies that benefit both Agency programs and national needs. The system will enable NASA to further prioritize the NASA Technology Portfolio investments against the Space Technology Roadmaps and the Space Technology Grand Challenges, as well as mission directorate needs.

The NASA Technology Portfolio Tracking System will provide an integrated, dynamic, Web-accessible interface allowing both internal and public engagement, and tracking of NASA technology investments through their life cycles, from proposal through project and product development. Its concept and development leverages the best practices, features and baseline knowledge of previously developed database systems. The system will store value-added information about NASA's technology investments, track technologies through various stages of maturity and facilitate mapping technologies to projects for management and accountability. This fiscal year, NASA planned to award a contract to develop the database system in time to see it completed by the end of the year, but due to delays in funding that resulted from the continuing resolutions, the award was not made until late summer. NASA expects to complete this work in FY 2012, and by the end of the fiscal year, the system should hold about 75 percent of the NASA technology portfolio programs' data.

## Outcome 3.4

Facilitate the transfer of NASA technology and engage in partnerships with other government agencies, industry, and international entities to generate U.S. commercial activity and other public benefits.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Establish 12 technology-related significant partnerships that create value for programs and projects. Track both quantitative dollar value and qualitative benefits to NASA (e.g., reduced volume or mass, improved safety) per year. | | | | | 3.4.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Establish at least 12 technology-related significant partnerships during FY 2011. | 7IPP! Green | 8IPP01 Green | 9IPP1 Green | None | ST-11-13 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Complete 30 technology transfer agreements with the commercial and academic community through such mechanisms as licenses, software use agreements, facility use agreements, and Space Act Agreements per year. | | | | | 3.4.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete at least 30 technology transfer agreements during FY 2011. | 7IPP2 Green | 8IPP2 Green | 9IPP2 Green | None | ST-11-14 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Successful application of Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) technologies into commercial products or services. | | | | | 3.4.1.3 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Greater than 35 percent of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase II technology projects awarded between 2004-2008 will be transferred into commercial products or services. | None | None | None | 10IPP04 Green | ST-11-15 Red |
| ***Why NASA rated APG ST-11-15 Red:*** Based on NASA's current measurement method, NASA determined that it awarded 23.7 percent of SBIR/STTR projects (182 of 766) between 2004 and 2008 and had extended them past Phase II. NASA believes the numbers of commercialization successes are greater than the current methods indicate. To achieve commercialization, these projects used either NASA Phase III funds or an alternative source of non-NASA funding to develop the technology. Commercialization is a metric broadly defined by the SBA as a measure of the ability of SBIR/STTR contractors to successfully receive non-SBIR/STTR revenues for broad market, as well as other government applications, for technologies they developed under the SBIR/STTR programs. At NASA, this is defined as the sum of technology "infused" into NASA programs (metric 3.1.1.4), procured by other government agencies, and/or used in the commercial marketplace. The collection of non-NASA applications for this metric requires the voluntary sharing of information by SBIR/STTR contractors with NASA personnel. NASA continues to consider alternative methods of data collection that will lead to increasing accuracy in the measurement of commercialization successes. (See page 157 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Document 40-50 of the most notable examples of successful transfer and commercialization of NASA-derived technology per year and publish in Spinoff annually. | | | | | 3.4.1.4 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Document at least 40 notable technology transfer successes in NASA's Spinoff publication. | None | None | None | 10IPP01 Green | ST-11-16 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Document, coordinate, and prioritize Agency-level technology strategic investments to ensure NASA has a balanced portfolio of both near-term NASA mission (pull) technologies and longer-term transformational (push) technologies that benefit both Agency programs and national needs. | | | | | 3.4.1.5 Green |

# Strategic Goal 4

# Advance aeronautics research for societal benefit.

As an industry, aviation contributes 1.3 trillion dollars to the Nation's economy and is responsible for ten million jobs in aviation related fields. Airlines in the U.S. transport over one million people daily, but during peak travel times the air traffic and airport systems in the United States are stretched to capacity. Environmental concerns, such as aircraft noise and emissions, limit increased operations and the expansion of airports and runways. NASA's Aeronautics Research Mission Directorate (ARMD) works to solve these critical challenges that affect the nation's air transportation system and growth of the economy, while improving safety of the system that is already the safest mode of transportation.

This graphic shows conceptual aircraft designs developed in the Advanced Vehicle Concepts studies. The purpose of the studies was to analyze potential configurations and technologies designed to simultaneously reduce noise, emissions and fuel burn. (Credit: NASA)

ARMD's four research programs conduct cutting-edge research at the fundamental levels and integrated systems levels to address these national challenges. That research supports current and emerging applications, as well as revolutionary concepts and technologies that could one day change the face of air transportation. ARMD's research portfolio is well aligned with the principles, goals, and objectives of the National Aeronautics Research and Development (R&D) Policy and Plan and directly supports the development of the Next Generation Air Transportation System, or NextGen. (Read more about NextGen plans at the Federal Aviation Administration (FAA) Web site http://www.faa.gov/nextgen/.)

ARMD's research is also enabled by its Aeronautics Test Program (ATP), which provides critical support to NASA's infrastructure needs (see Strategic Goal 5, page 133). ATP manages and makes strategic investments in the NASA-owned state-of-the-art ground test facilities and flight research assets to ensure ready access by NASA programs, other Federal agencies, and the private sector to test and evaluate research concepts and technologies.

ARMD fosters strong partnerships with other Government agencies, especially FAA and the Department of Defense (DoD). As a member agency of the multi-agency Joint Planning and Development Office (JPDO), NASA and partner agencies plan and coordinate the development of concepts and technologies required for NextGen.

## Benefits

NASA's aeronautics research program is the Nation's most comprehensive civil aeronautics research and development effort. This technological superiority is a key enabler for the U.S. industry to continue its position as the world leader in the aviation sector that has been bringing a positive trade balance of over $40 billion per year. The NASA-developed technologies are the DNA of almost all of the civil and military aircraft the U.S. aerospace industry has developed and marketed to date. NASA Aeronautics continues its tradition of developing and transferring innovative capabilities and technologies to U.S. industry and other government agencies, which in turn result in highly competitive U.S. products and superior capabilities that create and sustain high-technology, high-paying jobs boosting the U.S. economy. In the past couple of years, the U.S. aviation industry introduced highly competitive new aircraft and engine products into the global market. Below are a few examples of successful technology transfer NASA has made to the U.S. industry and to other government agencies.

Results from ARMD's fundamental research into high efficiency, low emissions combustion and light, high-temperature materials for jet engines from the 1990s and early 2000s have been incorporated by U.S. jet engine manufacturers, Pratt & Whitney (P&W) and General Electric (GE) in their next-generation aircraft engines (the Geared Turbofan (GTF) Engine and the LEAP-X engines, respectively). These engines feature more than 15 percent reduction in fuel burn and harmful emissions, and these competitive edges enabled P&W and GE to dominate the two global engine replacement programs: Boeing 737 MAX and the Airbus A320NEO. In the case of P&W, all new Bombardier C-Series and Mitsubishi Regional Jet selected the GTF engine as their launch product. As noted in the May 30, 2011, issue of *Time* magazine, job-creation associated with the P&W GTF engine is estimated to be in the hundreds of jobs per year in the high-paying manufacturing sector. The same competitive edges these engines present in decreased fuel burn, reduced emissions, and lower noise will directly benefit the flying public and communities adjacent to the Nation's airports helping to ensure the long-term viability of the U.S. air transportation system.

By addressing a current problem and making a timely transfer of the needed technology, we are helping our critical government partner for NextGen, FAA, to realize benefits in near term applications. NASA developed the Ground Delay Program (GDP) that combines National Weather Service real-time data with Air Traffic Control departure scheduling. FAA along with NASA's support conducted trials of this new capability at San Francisco Airport (SFO) this summer and demonstrated a significant reduction in ground delays due to morning fog compared with the current ground delay policy at SFO, which often leads to excessive and unrecoverable delays affecting the entire country.

NASA has open-sourced key data mining software for analyzing flight data recorder output through a collaborative Web site with over 300 members, known as DASHlink. Southwest Airlines (SWA) acquired sequenceMiner and Orca, two advanced anomaly detection techniques, through DASHlink. Early application of these techniques to data from 7200 SWA flights uncovered flight anomaly events that were not detected by SWA's existing analysis methods. Events flagged by these software tools are being added to SWA's daily operations review to improve operational performance. Southwest Airlines plans to incorporate these software tools into daily use to better manage their fleet of 305 planes that fly over 1,600 flights per day.

ARMD collaborates with universities for conducting cutting-edge, fundamental research with a built-in support for the science, technology, engineering and mathematics (STEM) education. For example, ARMD's NASA Research Announcements (NRAs) make significant investment in university research, which encourages participating undergraduate and graduate students to work with NASA researchers and its industry partners. NASA Aeronautics Scholarship Program also provides tuition support and funds student recipients to spend a summer working with NASA researchers at NASA Research Centers. These direct interactions and hands-on experience have been helping to inspire students toward future careers in the STEM professions.

## Risk to Achieving Strategic Goal 4

NASA purposely pursues very challenging and high payoff aeronautics research goals to bring about revolutionary advancement, not incremental improvement, in technologies and concepts. With inherently high-risk research, the potential for not meeting any specific research metric is always present. NASA is still committed to performing such research, and seeks to ensure that our research—even for those cases where the intended results were not achieved—provides valuable knowledge. These risks are mitigated by making certain that NASA's work is relevant to national needs, closely coordinating and collaborating with external partners, and ensuring technical excellence and rigorous technical and program management.

# Outcome 4.1

## Develop innovative solutions and advanced technologies through a balanced research portfolio to improve current and future air transportation.

NASA, through the Aeronautics Research Mission Directorate (ARMD), plays a key role in the discovery and development of the innovative solutions and advanced technologies required for the Next Generation Air Transportation System (NextGen). This includes pursuing technologies that are in their infancy today, developing the knowledge necessary to design radically new aviation systems, and enabling efficient, high-confidence design and development of revolutionary vehicles. These improvements must take place without compromise to the current safety record of the aviation industry.

Each of ARMD's fundamental aeronautics research programs contribute significantly in addressing the challenges of the current and future air transportation system. Below are summaries of their major contributions to this outcome for FY 2011.

### Developing advanced technologies to improve air transportation system safety

The extremely high safety record of the National Airspace System (NAS) is a credit to the on-going vigilance of operators, manufacturers, and regulators and past investments in technology. But even with very low accident rates, the United States always strives to improve this record, and NASA contributes to this continuous improvement through innovation to meet the remaining and emerging safety challenges. ARMD's Aviation Safety Program develops innovative algorithms, tools, concepts, and technologies that will improve the safety attributes of current and future aircraft operating in the NAS, identify and control emerging hazards, and overcome aircraft safety-related barriers that could impede full realization of NextGen.

#### *NASA explores damage-tolerant materials to improve aircraft safety*

This fiscal year, researchers in the Aviation Safety Program successfully demonstrated self-healing concepts to mitigate damage in aircraft structural elements, helping to improve aircraft safety.

Initiation and propagation of damage generally results in failure of aircraft structural components. Additionally, typical structural repairs often result in damaging practices, where material is ground away and holes are drilled to secure patches, which can act as new sites for damage. The proposed self-healing system provides a non-intrusive means to mitigate damage and is a significant foundation for future self-healing systems.

Demonstration results have shown the ability to mitigate fatigue crack spread in metals and to mitigate the effects of impacts on compressive strength in composites. For metals, a heat-activated self-healing material is drawn into fatigue cracks. The material successfully reduced the crack tip driving force of two aerospace materials (aluminum and titanium alloys), dramatically slowing the spread of the crack. For composites, the program developed a carbon fiber reinforced composite with a commercially available thermoplastic resin, which self-heals after ballistic impact and through-penetration. A healing effect was demonstrated in the developed composite materials by heating these materials under pressure. These capabilities suggest that a healing system can be scaled up to provide self-healing to damaged structural aircraft components.

Work supporting this research and other program accomplishments was done in close cooperation with the program's many partners from industry, academia, and other Federal agencies. The program also published numerous technical papers, gave presentations at conferences, and worked with partners to transfer key technologies.

### Developing innovative solutions and technologies to enable the NextGen

The Airspace Systems Program addresses the fundamental air traffic management research needs of increasing capacity, improving efficiency, and reducing the environmental impact of aviation in NextGen in collaboration with its partners in government, industry, and academia. The program works to directly benefit the flying public by moving key concepts and technologies from the laboratory into the field to facilitate the transfer of technology to end users. Concept simulations and field trials in real flight environments of NASA developed technologies have demonstrated the potential annual savings of tens of millions of dollars to airspace users through reduction in flight delays and fuel usage.

### *NASA continues research to improve air traffic management to make air travel more efficient for the benefit of the flying public*


The NASA Ames Airspace Operations Laboratory is a high-fidelity simulation environment for prototyping and testing advanced air traffic management concepts. The laboratory provided the environment to develop the FBTM tools, which support situation assessment (e.g., load tables, load graphs, traffic display with weather and filters), multi-trajectory trial planning, and ground-to-ground coordination of plans and clearance requests. These tools can be configured for traffic management units, multi-sector planning, or area supervisor positions. (Credit: NASA)

Researchers in the Airspace Systems Program conducted work in tools and methods for in-flight "flow-based trajectory management" in the NextGen. Flow-based Trajectory Management (FBTM) is a process for solving local airspace problems by modifying flight paths, or trajectories, of one or more aircraft. These operations provide a practical way to maintain efficient operations in the face of changing local and downstream conditions. Solving the technical challenge of managing in-flight trajectories that extend beyond currently available planning horizons provides one step toward accommodating increasing capacity in the airspace.

The concept of FBTM has evolved through a series of studies that began in 2006 and culminated this year in a study completed by the joint NASA–Federal Aviation Administration (FAA) FBTM Research Transition Team (RTT). NASA uses the joint agency RTT to conduct research and field-trials to accelerate acceptance of new air traffic management procedures. For the study, the RTT modified current air traffic management procedures to distribute FBTM responsibilities within a "planning team" comprised of traffic management and area supervisors.

The study demonstrated that FBTM is an effective method for managing future aircraft operations. The RTT successfully managed air traffic levels 30 percent greater than today's level. FBTM also can be integrated effectively into today's operations without additional resources. The RTT provided simulation results and tool requirements to FAA as technology transfer to inform FAA acquisition planning. The results also inform 10 out of 50 Operation Improvements as described in the FAA's NextGen Implementation Plan (released March 2011 and available at http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf). The study is an example of successfully transitioned research results from NASA to FAA and government collaboration using the RTT model. Read more about the study in a paper produced by the Joint Planning and Development Office: http://www.jpdo.gov/library/20110712_JPDO_Paper_FBTM_Result_v1.4.pdf.

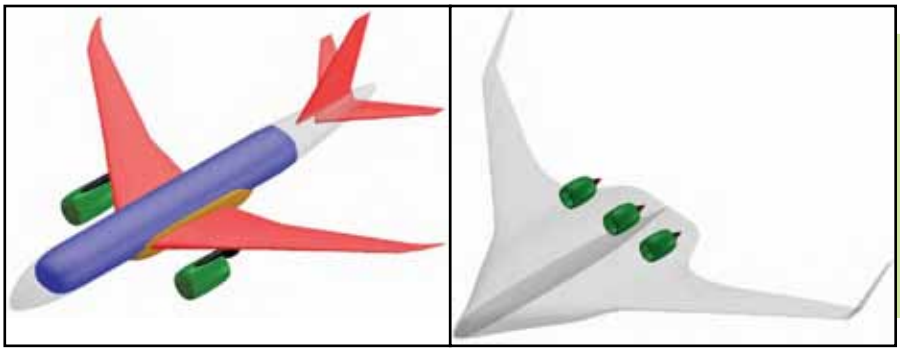
## Developing tools, technologies, and knowledge that improve performance and new capabilities for future air vehicles

The Fundamental Aeronautics Program seeks to enable a future where a variety of advanced aircraft improve the flexibility, efficiency, and environmental impact of air travel by developing tools, advanced technologies, and scientific knowledge necessary for the design of new types of vehicles. The program conducts research on topics such as advanced vehicle configurations and concepts, lighter, stronger materials and structures, fuel efficient and less polluting propulsion systems, advanced concepts for increasing lift and reducing drag, advanced computational tools and capabilities, and modeling and simulation for efficient future air vehicle design.

Advances in future air vehicles demand environmentally sensible and innovative aeronautics technologies and concepts that demonstrate significantly better performance and higher fuel efficiencies, and reductions in noise and emissions across different flight regimes, such as subsonic, supersonic, and hypersonic. The Fundamental Aeronautics Program, through its four projects—Subsonic Fixed Wing, Subsonic Rotary Wing, Supersonics, and Hypersonics—conducts in-house foundational and cross-cutting research across a broad range of research topics to meet these technology goals.

### *NASA studies methods to enable advances in future vehicles*

In FY 2011, researchers completed and validated the second generation of a multi-disciplinary analysis and design toolset used to evaluate the trades between noise, emissions, and performance of future subsonic fixed wing aircraft. Predictions of both conventional (e.g., a Boeing 737-800 used for commercial transportation) and unconventional (e.g., a hybrid wing body) aircraft performance—noise, emissions, fuel-burn, takeoff and landing performance, and aircraft weight—compared well to second generation validation targets. These new tools are used to develop new configurations and assess the introduction of new technologies that allow significant improvements in performance for future



The figure on left is a conventional tube and wing aircraft configuration and the figure on the right is an unconventional aircraft configuration such as a hybrid wing body. (Credit: NASA)

aircraft. These tools also are used to help guide future research to help select and develop the technologies that will have the most impact on an integrated design.

NASA research in subsonic rotary wing focuses on speed and range increases, payload capacity, noise reduction, propulsive efficiency, and rotorcraft unique technologies to enable development of new configurations that enhance mobility of the future air transportation system. This includes maturing technologies—e.g., technologies related to icing, crashworthiness, condition based maintenance, low noise flight operations, damage mitigation—needed for civil, commercial operations.

In FY 2011, researchers focused on developing methodologies to certify crashworthy designs by analysis, which minimizes the need for costly full-scale testing. The program used test data obtained from full scale crash tests of a MD-500 helicopter, conducted in December 2009 and March 2010, to calibrate and validate finite element models that contained detailed representations of airframe, seats, occupant, and external energy absorbers. Results and comparisons were very encouraging: the models predicted the pilot floor acceleration response within ±10 percent of the target.

The significance of this result is that survivability envelopes for a range of velocities, attitudes, and terrains can be developed from both tests and system-integrated models with a higher degree of confidence. As the technology evolves to efficiently incorporate more modeling and simulation into the design process, next generation rotorcraft will contain more crashworthy features without sacrificing weight and performance.

The images at left show a comparison between a full-scale MD-500 helicopter crash test (right) and a finite-element model representation of the same event. NASA used test data from instrumentation and video photogrammetry to calibrate and validate the finite element models. (Credit: NASA)

## Outcome 4.1

Develop innovative solutions and advanced technologies through a balanced research portfolio to improve current and future air transportation.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Transfer knowledge to the aviation community to better manage safety in aviation. | | | | | 4.1.1.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Demonstrate scalable anomaly detection on heterogeneous data. | None | 8AT04 Green | 9AT1 Green | 10AT01 Green | AR-11-1 Green |
| Demonstrate self-healing material concepts to mitigate damage in structural elements. | None | 8AT04 Green | 9AT1 Green | 10AT01 Green | AR-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| HPPG: Increase efficiency and throughput of aircraft operations during arrival phase of flight. | | | | | 4.1.2.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Conduct simulations of initial tactical conflict prediction and resolution advisory functions to address reduction in false alerts and increase in time to detect a loss of separation in terminal operations. | None | 8AT05 Green | 9AT5 Green | 10AT05 Green | AR-11-3 Green |
| Specify operational requirements for performing Multi-Sector Planning (MSP) functions in the mid-term, including technical and conceptual requirements, with consideration of how requirements might change as the National Airspace System (NAS) evolves towards NextGen. | None | None | None | 10AT06 Green | AR-11-4 Green |
| HPPG: Report on Human-In-the-Loop (HITL) Simulation and model results. | None | None | None | 10AT14 Green | AR-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Deliver tools, technologies, and knowledge that can be used to more efficiently and effectively design future air vehicles and their components that overcome national performance and capability challenges. | | | | | 4.1.3.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Achieve validated accuracy for conventional and unconventional aircraft, respectively, for nitrogen dioxide (NOx), takeoff and landing performance, cruise performance, take-off gross weight (TOGW), and noise. | None | 8AT07 Green | 9AT7 Green | 10AT07 Green | AR-11-6 Green |
| Demonstrate the ability to predict the effect of impact dynamics on a full-scale airframe within 10 percent of measured acceleration. | 7AT4 Green | 8AT09 Green | 9AT8 Green | 10AT08 Green | AR-11-7 Green |
| Demonstrate the ability to optimize a baseline aircraft design to simultaneously achieve high cruise efficiency and low sonic boom using Multidisciplinary Analysis & Optimization (MDAO) with a two-week cycle time. | None | 8AT11 Yellow | 9AT9 Green | 10AT09 Green | AR-11-8 Green |
| Validate NASA propulsion Computational Fluid Dynamics (CFD) codes using Hypersonic International Flight Research Experimentation (HIFiRE) scramjet flight data and ground-based test results. | None | None | 9AT10 Yellow | 10AT10 Yellow | AR-11-9 Yellow |

***Why NASA rated APG AR-11-9 Yellow:*** This annual performance goal was not met, in this fiscal year, and is expected to be accomplished in the June/July 2012 timeframe. To validate the Computational Fluid Dynamics (CFD) code, NASA is gathering this data on the Hypersonic International Flight Research Experimentation (HIFiRE) #2 vehicle's scramjet, while in flight. The Air Force has moved the date for the HIFiRE #2 vehicle launch until Summer 2012. (See page 174 for the Performance Improvement Plan.)

# Outcome 4.2

## Conduct systems-level research on innovative and promising aeronautics concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.

To complement NASA's investment in fundamental research, the Integrated Systems Research Program (ISRP) conducts research on integrated system-level vehicle and airspace system concepts and technologies, and demonstrates their intended and integrated benefits in a relevant environment. By doing so, one of the ISRP's main goals is to accelerate the transition of aeronautics research and development results, including NextGen technologies, to users in industry and government. Research is coordinated with the Aeronautics Research Mission Directorate's (ARMD's) fundamental research programs and with relevant efforts by other Federal agencies and industry.

Currently, ISRP research is focused on technologies to reduce the environmental impact of aircraft (in terms of local and global emissions, local air quality, and noise) and integration of Unmanned Aerial Systems (UAS) into the National Airspace System (NAS). The United States is highly dependent on the health of the aviation and aerospace industry as it contributes to economic activity via the transport of passengers and cargo domestically and abroad and to homeland security. The ability to transport people and goods point-to-point domestically and internationally is critical to all levels of the economy. Furthermore, it is essential that this ability be realized with flexibility, affordably, and in an environmentally responsible manner.

ISRP's Environmentally Responsible Aviation (ERA) project focuses on selecting vehicle concepts and technologies that can simultaneously reduce aircraft fuel burn, noise, and emissions. Today's aircraft already benefit from NASA investments in aeronautical research that have yielded improved fuel efficiencies, lowered noise levels, and reduced harmful emissions. Although substantial progress has been made, much more needs to be done. The Nation's air transportation system is expected to expand significantly within the next two decades. Clearly there is a potential adverse impact from this expansion on the environment. The ERA project invests in technologies with the potential to substantially reduce the environmental impact of aviation.

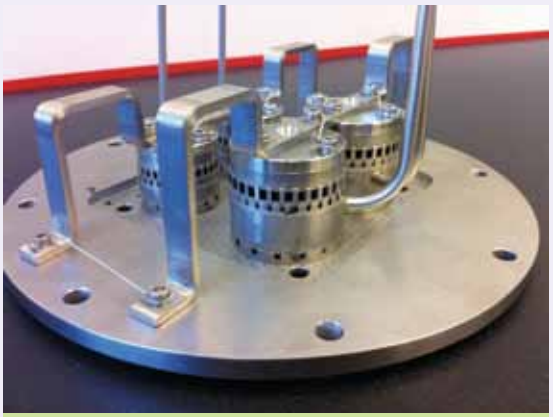
Research in the ERA project is focused in three main areas: Airframe Technology, Propulsion Technology, and Vehicle Systems Integration. Together, they help industry enlarge the viable trade space—the degree to which performance objectives can be traded against each other to achieve the best overall value—to help in designing and building the most environmentally efficient commercial aviation vehicles.

### *NASA helps make aircraft more environmentally friendly*

During FY 2011, research in the propulsion technology area focused on significantly reducing harmful nitrogen oxide (NOx) emissions while reducing fuel burn in aircraft engines. This involved the development and demonstration of new aircraft engine combustor concepts that efficiently mix the fuel and air to maintain a stable combustion process and minimize the formation of NOx emissions.

NASA worked collaboratively with industry to develop and test a variety of advanced concepts. Both Pratt & Whitney and GE Aviation demonstrated several new combustor concepts that have the potential to reduce NOx emissions by as much as 75 percent relative to aircraft flying today. Over the next several years, NASA will work with these companies to mature these advanced combustor concepts and assess the feasibility of incorporating them into future aircraft engines.

NASA and its partners will use NASA facilities that simulate aircraft engine conditions to validate the combustor performance, operability, and reduced emissions at conditions consistent with the full range of aircraft engine power settings. Combustor testing is expected to demonstrate a reduction of landing and take-off NOx emissions to



The Counter Rotating External Staged Swirler (CRESS) concept is one of two Lean Direct Injection concepts developed by Pratt & Whitney that achieved greater than 75 percent NOx reduction in a flametube rig at low power settings. (Credit: NASA)

75 percent below the goals recommended at the sixth meeting of the Committee on Environmental Aviation Protection, which helps formulate standards and recommended practices on aircraft noise and aircraft engine emissions. In addition to meeting the emissions goals, the combustor must operate at conditions consistent with an aircraft/engine architecture designed to reduce fuel burn by 50 percent from current state-of-the-art aircraft and have the ability to use conventional, as well as synthetic, jet fuels.

## Outcome 4.2

Conduct systems-level research on innovative and promising aeronautics concepts and technologies to demonstrate integrated capabilities and benefits in a relevant flight and/or ground environment.

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Reduce technical risk by conducting research at an integrated system-level on promising aeronautical concepts and technologies in a relevant environment. | 4.2.1.1 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Optimize fuel injector designs through flametube and/or sector tests and demonstrate their performance in meeting futuristic aircraft emission goals. | None | None | None | None | AR-11-10 Green |

| Uniform and Efficiency Measures | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Deliver at least 86 percent of on-time availability for operations and research facilities. | 7AT8 Yellow | 8AT17 Yellow | 9AT12 Green | 10AT13 Green | AR-11-12 Yellow |

***Why NASA rated APG AR-11-12 Yellow:*** The on-time availability of the operations and research facilities managed by the Aeronautics Test Program, was 80 percent, slightly less than the targeted 86 percent availability. NASA did not meet its target, primarily due to the downtime, introduced with the failure of subsystems in two facilities at the Glenn and Langley Research Centers. At Glenn Research Center, the 8 foot by 6 foot Wind Tunnel, had unscheduled downtime to repair the Open Rotor Propulsion Rig (ORPR) forward balance, which has resulted in rescheduling testing into FY 2012. At Langley Research Center, the 14 foot by 22 foot Wind Tunnel experienced unscheduled downtime due to issues with the main drive lubrication system and the motor generator set. (See page 174 for the Performance Improvement Plan.)

# Strategic Goal 5

# Enable program and institutional capabilities to conduct NASA's aeronautics and space activities.

The supporting capabilities, services, and infrastructure that enable NASA's missions are naturally a strategic imperative, but this is the first time that NASA has had a strategic goal dedicated to mission support. This addition demonstrates NASA's acknowledgement of the challenges it currently faces in the mission support arena, as well as a commitment to performance achievement and improvement.

Successful mission support requires integration of all elements across organizational and functional boundaries and application of an Agency-wide view in making investment decisions. The linkage between NASA's mission portfolio and mission support elements must be understood through analyses to assess risks, opportunities, and efficiencies, and then acted upon. Integration requires a strong governance structure to harmonize policies and business practices, mitigate conflicting requirements, and enforce the internal controls that oversee the effectiveness, efficiency, reliability, and compliance of NASA's operations. NASA's mission support governance structure includes a decision-making process guided by short- and long-term considerations to create a balanced and integrated mission support portfolio. NASA uses an approach that is requirements-oriented (aligned with missions and external requirements) to provide basic Center operations and an optimal mission support environment.

Institutional capabilities encompass a broad range of essential technical and non-technical corporate functions for the entire Agency. The Agency's program capabilities include managing the scientific and engineering workforce and maintaining NASA-unique facilities, equipment, tools, and other required resources. For FY 2011, NASA focused its performance measurement on major efforts, like Shuttle workforce transition, activities that will affect much of the Agency, and important ongoing capabilities maintenance. A few of these activities, like launch services, are managed by mission directorates, but directly contribute to capabilities and infrastructure that support NASA's missions.

## Benefits

NASA's program and institutional capabilities ensure that NASA is able to fulfill its commitments to all stakeholders, while providing a safe and efficient working environment. Some of the benefits of these capabilities include the following:

- Safety and mission assurance capabilities protect the workforce and Agency assets, underpinning the success of all technical activities.
- Information, infrastructure, and security capabilities support the productivity of NASA's scientists and engineers.
- Launch, rocket propulsion testing, space communications, and aeronautics test services provide key capabilities for the technical activities of NASA and its partners.
- Capabilities in human capital management, finance, procurement, occupational health and safety, equal employment opportunity and diversity programs, and small business programs ensure that a well-qualified workforce representing a range of backgrounds and experience is available to meet Agency needs.

NASA also is addressing strategic themes such as affordability and sustainability for longer-term planning of program and institutional capabilities. Components of these themes include "green" initiatives and energy efficiency, workforce alignment and readiness, diversity, improved acquisition, and eliminating Center duplication of capabilities.

## Risks to Achieving Strategic Goal 5

**Meeting Changing Facilities Requirements.** An ongoing challenge is managing current facilities resources and capabilities and anticipating changes in needs. An important component of facilities management is updating, replacing or eliminating aging or obsolete facilities. The Agency is developing multi-year Center plans and an integrated Agency Master Plan, and is aggressively managing to reduce facility costs and improve overall capabilities. NASA seeks optimal solutions in how it conducts operations, often leveraging resources and opportunities offered by Agency partners or seeking products and services from commercial sources.

**Achieving and Sustaining State-of-the-Art Technologies for Institutional Capabilities.** To realize future cost, schedule, and quality improvements, NASA must stay current with technological progress. The Agency actively monitors the research and development work of other Federal agencies, industry, academia, and other nations. NASA conducts studies and planning activities Agency-wide to determine the potential mission applicability of emerging and maturing technologies. New tools, processes, and technologies improve capabilities and scientific returns, but cannot be predicted in advance. Institutional management processes must be sufficiently robust to maintain NASA research, testing, and operations capability, while allowing the Agency to adopt and benefit from the latest technologies and innovations. Recent examples include advancements in alternative fueling for fleet vehicles and in water reuse projects.

NASA's Ames Research Center and the Department of Energy (DOE), at the Lawrence Berkeley National Laboratory are collaborating on technologies and processes for what may be the "greenest," highest-performing building in the Federal government.

Originally developed for aerospace applications, NASA intelligent system software will be installed in the new building, called Sustainability Base (shown in the photo), by Ames engineers. These NASA-developed control and Integrated Systems Health Management (ISHM) technologies will be an integral part of the building. To help integrate these "smart system" technologies, the Building Technologies Department at Berkeley Lab developed a Building Information Model (BIM) to serve as the repository for the building's systems information during its life cycle. Using data from the BIM, Berkeley Lab developed an energy-performance simulation model to optimize the building's energy operations. (Credit: NASA)

**Managing a Distributed Infrastructure Base.** NASA's program management is distributed across numerous mission areas and geographically separated Centers and facilities. This presents challenges in implementing a consistent and cost-effective set of processes, systems, and tools. Differences in local and state policies, zoning and environmental regulations, and even energy costs impact the Agency's ability to create and implement a uniform approach. At every Center and facility, NASA works proactively and cooperatively with local, state, and Federal regulatory entities to mitigate possible negative impacts before policies or rules are finalized. By adhering to a common set of values and operating principles, but allowing for flexibility in implementation, NASA minimizes risk to missions and positions the Agency for success in future endeavors.

# Outcome 5.1

## Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.

NASA has a skilled, competent, and dedicated workforce. They are passionate about their work, and they bring many dimensions of diversity, including ideas and approaches, to make their teams successful. To continue the successful conduct of missions over the next 10 to 30 years, NASA must broaden, maintain, and sustain its diverse workforce with the right balance of skills and talents. The Office of Human Capital Management, NASA Education, and the Office of Diversity and Equal Opportunity work collaboratively to identify future needs and to identify gaps and potential shortfalls in skills. They also cooperatively plan Agency-level participation in new employee recruitment efforts.

NASA has established a Diversity and Inclusion Framework to increase the diversity of the workforce and the overall inclusiveness of the work environment. The framework takes the Agency beyond a focus on equal employment opportunity (EEO) compliance to policies and practices designed to enhance innovation, creativity, and employee engagement. Complementary to its diversity and inclusion efforts, the Agency works aggressively to identify and eliminate environmental factors that can diminish trust, impair teamwork, compromise safety, and ultimately undermine excellence. NASA conducts an annual self-evaluation as part of the Model EEO Plan, which is designed to identify and remove barriers to individual and team success. NASA continued to make progress in its efforts to become a model agency for EEO. For example, NASA continued to successfully implement programs designed to proactively prevent discrimination, such as conflict management, anti-harassment, and the provision of reasonable accommodations.

Below are some of the activities conducted during FY 2011 by the Office of Human Capital Management, the Office of Education, and the Office of Diversity and Equal Opportunity in support of this outcome.

### Creating a workforce with top technical and business management competencies

#### *Dedication to the Shuttle and NASA*

Workforce efforts in 2011 emphasized safe fly-out of the Space Shuttle and transition efforts to support the Agency direction in alignment with the NASA Authorization Act of 2010. With the successful completion of STS-135 on July 21, 2011, NASA demonstrated the ability to identify, cultivate, and sustain a workforce with technical and business management competencies to safely complete the Space Shuttle manifest and prepare the International Space Station for its post-assembly operations and utilization phase.

NASA had asked the Shuttle operations workforce—both civil service and contractors—to stay through the end of the Space Shuttle Program to safely complete the Shuttle's final mission. NASA and the Space Shuttle prime contractors worked closely together to develop and implement a range of tools and strategies to help safely manage operations through retirement. These strategies and tools included retention pay for the contractor workforce, developmental opportunities (technical and leadership), workforce sharing (matrix management, rotations, job sharing), communications, and recognition. NASA also implemented regular surveys of the Shuttle workforce and monitoring of attrition rates, which remained very low in 2011.

#### *Moving on from Shuttle*

To support transition of the workforce to NASA's future direction that aligns with the NASA Authorization Act of 2010, NASA conducted multiple job seeking training sessions (e.g., resume writing, interviewing, use of social media), as well as career counseling sessions for the workforce. NASA also continued management of the Space Shuttle Transition Liaison Office transition activities, including building relationships with other Federal partners like the Departments of Commerce and Labor, conducting two face-to-face meetings with affected Centers and communities, conducting two Federal government virtual job fairs, and partnering with the Office of Personnel Management (OPM) to conduct a Federal career fair at Kennedy Space Center on July 26, 2011 to provide opportunities for displaced contract workers. NASA's Office of Human Capital Management developed, deployed, and implemented a Workforce Transition Tool that provides the ability to track, plan, and status the impacted Shuttle employees as they transition to support other NASA technology development and space activities.

The NASA Human Resources team established a Kennedy Space Center Workforce Transition Office (WTO) in partnership with Brevard Workforce, a regional public–private partnership, to help facilitate a successful workforce transition across the Center. It is staffed by NASA Human Resources professionals who are available to offer guidance to employees—both civil servants and contractors—regarding Federal employment. Services include assistance with understanding Federal job announcements, applying for Federal employment, writing a Federal resume, interviewing tips and techniques, and personal transition referral services.

### *Getting employees' views of NASA diversity and inclusion*

At the same time, NASA made great strides with its diversity and inclusion efforts during FY 2011. The Agency deployed a survey to all employees designed to establish a baseline for employee viewpoints on diversity and inclusion related matters such as equitable allocation of career enhancing opportunities, facilitation of diverse inputs into strategic planning and decision-making, and effective communication between management and employees.

Some of the highlights of the 2010 Diversity and Inclusion Assessment Survey's findings included the following:

- Most respondents indicated that NASA policies promote fair treatment of employees (83 percent) and that NASA values employees with varied backgrounds and experiences (75 percent).
- Overall, a high percentage of employees gave positive responses regarding NASA creating a diverse and inclusive work environment, with high levels of agreement for fostering mutual trust and respect in the workplace (76 percent), valuing employee contributions (75 percent), and providing a supportive environment for every employee (72 percent).
- A high proportion of respondents reported feeling like a valued employee at NASA (72 percent) and that they could recommend NASA as a good place to work (79 percent).

Among the findings pointing to the need for additional steps to enhance diversity and inclusion at NASA were the following:

- Only 60 percent indicate that NASA is effective at educating employees on how diversity and inclusion foster innovation. Further, 68 percent of respondents reported that diversity and inclusion led to innovative ideas, yet only 45 percent agree that NASA uses diversity and inclusion effectively to increase workforce productivity, and only 32 percent disagree with the statement that NASA's efforts to achieve workforce diversity and inclusion sometimes lead to workplace problems.
- Less than half (49 percent) of respondents agreed that supervisors and managers help employees to recognize biases that foster workplace discrimination or exclusion.

### *NASA as a Model Equal Employment Opportunity Workplace*

In its continuing efforts to become a model organization for EEO, NASA set an ambitious agenda in FY 2011 for workforce participation. Currently, NASA is at or above the relevant civil labor workforce participation rates for women and most race/ethnicity groups. Additionally, the Agency's statistics for individuals with targeted disabilities also are consistent with government-wide numbers.

NASA's goal to be a model for EEO requires continuous and aggressive improvement efforts. The Model EEO Plan contains 57 actions, which grew out of the Agency's self-assessment of where it stands in its efforts to better ensure a workplace environment conducive to every employee reaching his or her full potential. To meet this ultimate objective, NASA designed the plan's actions to enhance recruitment, retention, and professional development opportunities for all employees and all EEO groups. Consistent with this approach, NASA sought to complete 40 of the 57 actions in the first year of the plan alone. The Agency fell short of its targets in FY 2011, but will continue to improve the plan and work toward making the work environment increasingly free of barriers.

### *Effective labor management*

To enable institutional capabilities and in support of substantive mission transition, NASA focused significant effort in restructuring the labor funding and associated processes. In FY 2011, NASA's Office of Human Capital Management led the effort and successfully implemented labor funding and full time equivalent (FTE) planning structures, created a new workforce process for the labor formulation process used to support the Planning Programming Budgeting and Executing (PPBE) formulation cycle, and developed a new labor execution approach called GOLD (Governance of Labor Distribution). These capabilities help ensure that moving forward all NASA workforce is assigned to NASA missions, and

by allocating FTE and dollars by mission and center, ensures that there are no unfunded FTE. These workforce planning structures and processes provide NASA a well-documented and clear foundation, which programs and institutional capabilities can use to align the workforce to successfully conduct NASA's missions.

NASA focused on communications to enhance NASA's inclusive work environment. In support of communications in 2011, NASA sustained effective labor-management dialogues through the Labor Management Forum (LMF). NASA successfully conducted six LMFs in 2011. These were held on November 19, 2010 and on January 25, March 10, May 26, July 22, and September 22, 2011. The topical areas addressed include usage of term appointment authority, a review of the Agency performance management process to address concerns about discrimination, and a discussion of line management and program management communication issues.

## Building tomorrow's workforce by attracting students to STEM-related disciplines

### *Attracting student participation that is as diverse as the Nation*

NASA assists minority institutions and faculty through multi-year research grants and provides scholarships, internships, mentoring, and tutoring to underserved and underrepresented students. Through the Minority University Research and Education Program (MUREP), students attend Minority Institutions, including Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Hispanic-Serving Institutions, and participate widely in NASA's research and education programs and its overall Mission.

Many of these efforts also have had notable success in attracting women. Through participation on the White House Council for Women and Girls, NASA takes into account the needs of women and girls in the policies the Agency drafts, as well as the education programs that are supported. Having greater numbers of female, underserved and underrepresented students participating in NASA programs supports the entry of these students into the scientific and technical workforce as well as their pursuit of advanced science, technology, engineering, and mathematics (STEM) degrees.

The NASA higher education program that receives the largest share of Agency education funding, and thus serves the largest number of higher education students nationwide, is the National Space Grant College and Fellowship Program (Space Grant). The NASA Space Grant Program Office has an established expectation of 40 percent female participants among each of its 52 consortia. Additionally, the Space Grant consortia are accountable for improving and maintaining the participation of underserved and underrepresented students in their programs. State-specific goals for underserved and underrepresented participation are established for each Space Grant consortium according to National Center for Education Statistics higher education enrollment figures. The cultivation of diversity is both a management philosophy and core value for all NASA education efforts. Diversity of the skills and talents needed in its future workforce is critical to NASA's success. Potential at both the individual and organizational levels is maximized by fostering awareness, understanding, and respect for individual differences. The knowledge, expertise, and unique background and life experiences, including the race, ethnicity, and gender, of each individual serve to strengthen the Agency.

### *Global Climate Change Education at Minority Serving Institutions*

In June 2011, MUREP awarded $7.2 million in cooperative agreements to 14 minority-serving organizations across the United States to enhance learning through the use of the Agency's Earth Science resources. The winning proposals illustrated innovative approaches using NASA content to support undergraduate teaching and learning, with particular emphasis on engaging students using NASA Earth observation data, Earth system models, as well as providing climate-related research experiences for teachers and undergraduate students.

### *Minority Innovation Challenges Institute*

Also in June, the NASA Minority Innovation Challenges Institute (MICI) announced opportunities for minority serving institutions to apply for a $5,000 grant to enter the University Student Launch Initiative (USLI) or Lunabotics Mining Competition.

MICI is designed to inspire minority undergraduate students to pursue advanced degrees and careers in science, technology, engineering and math disciplines critical to NASA's future missions. USLI challenges students to design, build, and launch to an altitude of one mile a reusable rocket with a scientific or engineering payload. The project engages students in scientific research and real-world engineering processes with NASA engineers at NASA's Marshall Space Flight Center in Huntsville, Alabama. The Lunabotics competition, which takes place at NASA's Kennedy Space Center in Florida, challenges students to design and build remote controlled robots that can excavate simulated lunar dirt. During the event, the teams' designs, known as lunabots, will go head-to-head to determine which one can collect and deposit the most dirt within 15 minutes.

### *Tribal College and University Project (TCUP)*

In 2011, MUREP's TCU project provided NASA engineering expertise to help establish an accredited Bachelor of Science degree in Computer Engineering at Salish Kootenia College in Montana, the first four-year engineering program offered by any of the 36 tribal colleges in the United States. Additionally, the project has helped remove many of the barriers to Native American student participation in NASA competency building and research opportunities by providing an "externship" program in which the initial three weeks of the program are held at a tribal college (United Tribes Technical College in North Dakota). The remaining seven weeks are conducted at the home institutions of the Tribal College students and faculty mentors. In FY 2011, 36 students and faculty from nine TCUs participated.

## Outcome 5.1

Identify, cultivate, and sustain a diverse workforce and inclusive work environment that is needed to conduct NASA missions.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Define and build the workforce skills and competencies needed for the Agency's future directions in technology development and deep space exploration. | | | | | 5.1.1.1 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Seventy-five percent or more of Shuttle workforce has been realigned for new Agency needs.. | None | None | None | 10WF06 White | AMO-11-1 Yellow |
| ***Why NASA rated APG AMO-11-1 Yellow:*** NASA did not meet the target for this annual performance goal as a result of Congressional budget action. The addition of a Shuttle mission and delays in the mission manifest resulted in a slower than planned transition of workforce from the Space Shuttle Program. Additionally, the year-long Continuing Resolution significantly delayed the start of new programs to which NASA planned to transition the Space Shuttle workforce. (See page 184 for the Performance Improvement Plan.) | | | | | |
| Twenty percent or more of annual recruitments will be through the early career hiring initiatives. | None | None | 9ED5 Green | 10ED04 Yellow | AMO-11-2 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Build skills across all levels of the workforce through Leadership Development Opportunities. | | | | | 5.1.1.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Evaluate current state of Agency leadership training and development and publish findings and recommendations in a comprehensive report to guide future program direction. | None | None | None | None | AMO-11-3 Green |
| Seventy-five percent of the Agency's leadership training and development programs include "leading through transformation" content. | None | None | None | 10WF04 Green | AMO-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Achieve and sustain an effective labor-management dialogue. | | | | | 5.1.1.3 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Identify and address at least three significant labor-management challenges identified during the year during periodic Agency-led Labor Management Forums. | None | None | None | None | AMO-11-5 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Adopt and respond to innovative employee feedback mechanisms. | | | | | 5.1.1.4 Green |

| FY 2011 Annual Performance Goal | FY 07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Identify and address at least two topics that employees identified in the latest Federal Employee Viewpoint Survey. | None | None | None | None | AMO-11-6 Yellow |

***Why NASA rated APG AMO-11-6 Yellow:*** This annual performance goal was not met. Many of the planned activities were completed but several have been delayed into FY 2012. Specifically, the identified areas to be addressed, and their corresponding action plan, are as follows:
1) Continue focus on teamwork/working together to ensure mission success. Planned actions included continual monitoring of Shuttle workforce concerns through regular surveys; and instituting a team-building focus in Agency leader development programs. The activities toward this topic were completed in this fiscal year.
2) Ensure that recognition and rewarding of employees is fair, consistent, and based on results-oriented performance. The planned actions included educating and training supervisors, through Agency supervisory training courses; and implementing recommendations for enhancing the Agency's Honor Awards Program. Both of these planned actions were delayed into FY 2012. This years funding level removed the option for conducting further Agency supervisory courses in FY 2011. Additionally, the development of new policies surrounding the Agency Honor Awards Program, is taking more time than planned, resulting in a delay until FY 2012. (See page 182 for the Performance Improvement Plan.)

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Establish and maintain a workplace environment free of illegal discrimination, harassing conduct, and retaliation for Equal Employment Opportunity (EEO) activity and that provides reasonable accommodations to individuals with disabilities. | 5.1.1.5 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Complete FY 2011 actions described in the NASA Model Equal Employment Opportunity (EEO) Agency Plan. | None | None | None | 10WF01 Green | AMO-11-7 Yellow |

***Why NASA rated APG AMO-11-7 Yellow:*** NASA made significant progress on many of 57 activities, contained in the Model EEO Agency Plan for FY 2011-2013, which have efforts in fiscal year 2011, but did not complete all the planned actions. NASA sought to complete 40 of the 57 actions in the first year of the Plan alone. NASA completed 14 of these actions (35 percent). In addition, NASA completed five actions not targeted for completion until FY 2012. Of the other actions targeted for completion in FY 2011, NASA has partially completed 19 (48 percent). NASA has completed key actions related to the Agency's Anti-Harassment Program, Conflict Management Program, and the Functional Review Program is on track for completion of its actions. However, as a result of recent Executive Orders that required development of action plans in FY 2010-2011 for Asian Americans and Pacific Islanders, Individuals with Disabilities, and Veterans, NASA had to add multiple actions to the Model EEO Agency Plan. The initial development of these plans, dispositioning of community group comments, and introduction of approximately 20 new actions, mid-year, did not allow time for full progress to be made. All efforts continue to progress, and are expected for completion before the end of the plan's timeframe. (See page 182 for the Performance Improvement Plan.)

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Implement an Agency-wide Diversity and Inclusion Framework to develop a more demographically diverse workforce and a more inclusive work environment. | 5.1.1.6 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Establish a baseline for diversity by developing and implementing an Agency-wide diversity-inclusion survey. | None | None | None | 10WF02 Green | AMO-11-8 Green |

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Assure that student participants in NASA higher education projects are representative of the diversity of the Nation. | 5.1.2.1 Green |

| FY 2011 Annual Performance Goals | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Achieve 40 percent participation of underserved and underrepresented (in race and/or ethnicity) in NASA higher education projects. | 7ED2 Green | 8ED03 Green | 9ED3 Red | 10ED03 Yellow | ED-11-1 Yellow |

***Why NASA rated APG ED-11-1 Yellow:*** This annual performance goal was not met. Out of the 15,947 participants in NASA higher education programs who self-reported their race and ethnicity, 35 percent, reported being a member of an underserved or underrepresented race or ethnic group. NASA's aggressive goal of 40 percent, exceeds the national averages for underserved and underrepresented participation in higher education, and was a challenge that the Agency chose to undertake. The participation in NASA's programs did meet or exceed the percentages of underrepresented minorities pursuing higher education studies in STEM fields nationwide (between 11 to 21 percent of these degrees, at the bachelor level, according to the National Science Foundation Report, Women, Minorities and Persons with Disabilities in Science and Engineering: 2011). (See page 184 for the Performance Improvement Plan.)

| | | | | | |
|---|---|---|---|---|---|
| Achieve 45 percent participation of women in NASA higher education projects. | None | None | None | None | ED-11-2 Yellow |

***Why NASA rated APG ED-11-2 Yellow:*** This annual performance goal was not met. Out of the 15,568 participants in NASA higher education programs who self-reported their gender, 39 percent, reported being female. Albeit a greater number of women currently pursue higher education studies in the United States, men pursue a higher proportion of the degrees in science and engineering fields. For example, compared with men, women earn degrees at medium to low levels in physical sciences and mathematics (between 30 to 44 percent of these degrees), and at low levels in computer science and engineering (between 18 to 27 percent of these degrees). Despite the statistics, NASA still chose to set an aggressive goal of 45 percent, and fell just short of the challenge. (See page 184 for the Performance Improvement Plan.)

# Outcome 5.2

## Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.

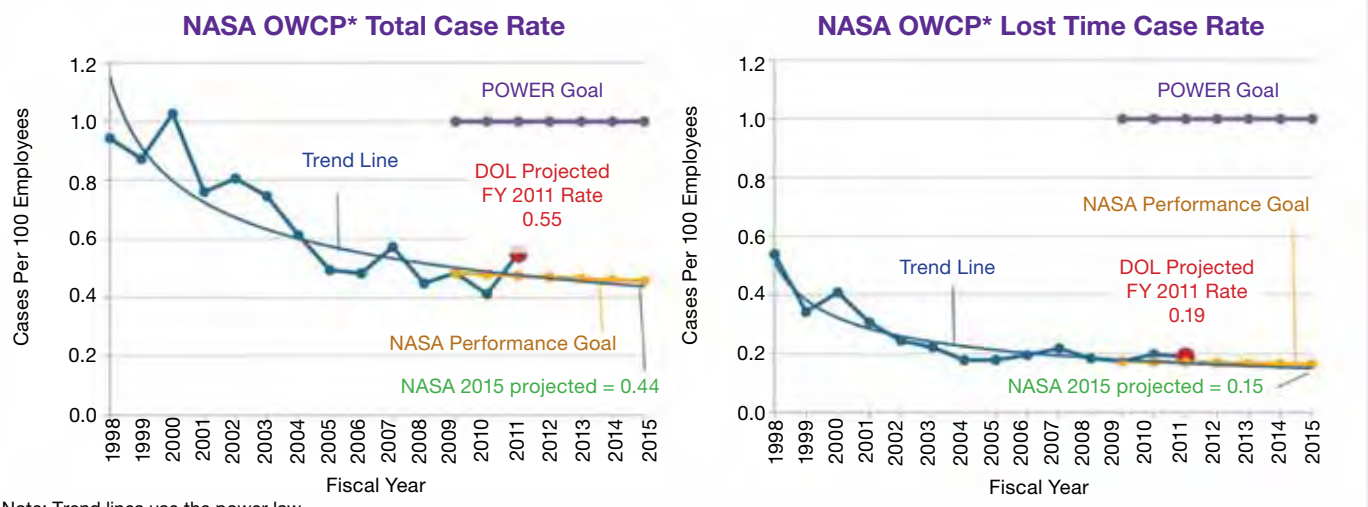
NASA's assets are critical to enable mission success. NASA plans for, operates, and sustains the infrastructure that provides the programs and projects with the facilities, capabilities, tools, and services they require. Toward this end, NASA performs periodic Agency-level integrated assessments of the supply of technical capabilities across all Centers and integrated analyses of the demand for these capabilities across all programs. This provides NASA with core information needed to balance institutional supply with program and project demand to ensure that capabilities are affordable and aligned with long-term strategic goals.

Several offices contribute to the achievement of this outcome. The Office of Safety and Mission Assurance assures the safety and enhances the success of all NASA activities through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, and quality assurance policies and procedures. The Office of the Chief Information Officer (OCIO) delivers reliable, innovative, and secure information technology (IT) services critical to all aspects of the Agency's operations. The Office of Strategic Infrastructure ensures that facilities and assets are appropriate and available to meet mission needs. This includes identifying assets and facilities that NASA no longer needs, maintaining and upgrading those in use, building or acquiring as needed, transitioning assets and facilities to new programs, and planning strategically for future needs. For FY 2011, these offices conducted the following activities.

### Maintaining safety, quality, risk assessment, reliability, and maintainability as integral features of all programs and operations

#### *Success starts with safety*

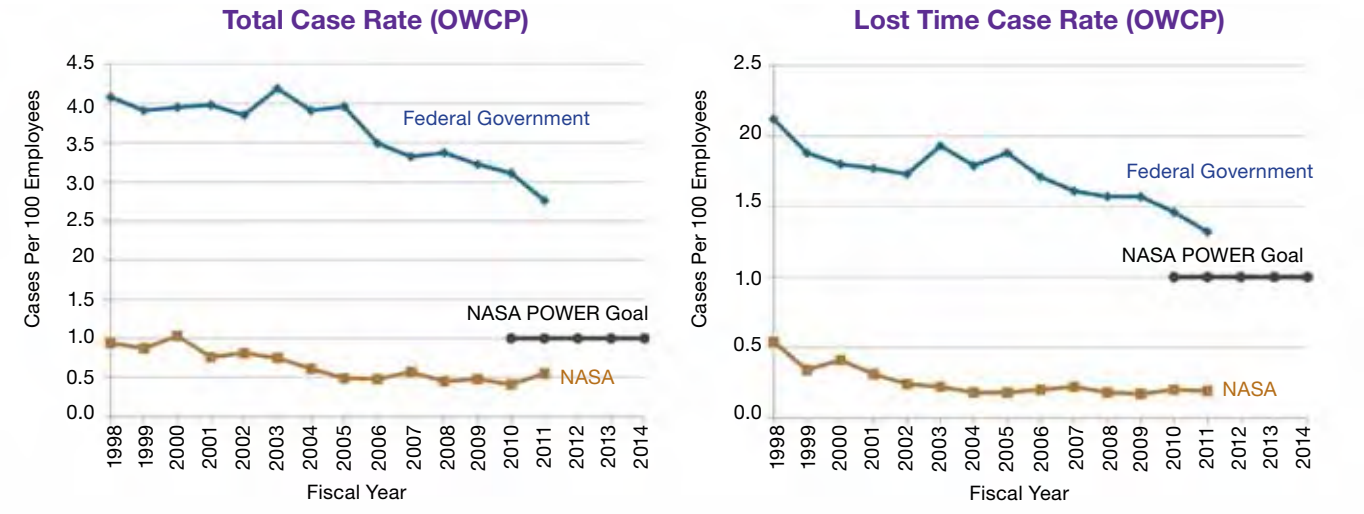
In addition to targeted initiatives, NASA must maintain a very high level of vigilance in its day-to-day operations to assure the continued availability of key assets and personnel. Key disciplines include the Safety and Mission Assurance program, which in 2011 continued to refine policies, procedures, and technical standards and provide programs of emphasis that will better enable NASA's programs and operations to achieve mission success via the mishap prevention efforts, as well as providing operational surveillance of hazardous operations, and independent assessments providing "checks and balances" of key programmatic decisions.




Note: Trend lines use the power law.

*Office of Workers Compensation Programs

FY 2009 (NASA's baseline year), the total number of cases was 89. At the end of the third quarter, the Department of Labor (DOL) projected the total number of cases for FY 2011 would be 101, which equates to a projected end of year total case rate of 0.55 (left chart). In FY 2009, the total number of lost time cases was 32. At the end of the third quarter, DOL projected number of lost time cases for FY 2011 would be 35, which equates to a projected end of year lost time case rate of 0.19 (right chart). Both charts show that NASA is well below the goal set for the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative and projects that it will remain below the POWER goal through 2015. However, for FY 2011, NASA challenged itself to improve injury rates even further, by decreases of one percent per year, despite the POWER goal exception for agencies having a rate below one case per 100 employees. (Credit: NASA)




Source: Occupational Safety and Health Administration, "Federal Agency Safety and Health Occupational Injury and Illness Statistics."
Note: Case rates are derived from claims submitted to the OWCP.

For the FY 2011 total case rate and lost time case rate, NASA currently is below the POWER goal, below the rate for the Federal government as a whole, and below the rate for other comparable Federal government agencies. However, NASA has challenged itself to improve injury rates even further, and decreased one percent per year, despite the POWER goal exception for agencies having a rate below one case per 100 employees. (Credit: NASA)

## Providing efficient, effective, and secure IT services for NASA and for dissemination of information to the public

Given the technically advanced, complex, high-risk nature of NASA's work, information technology (IT) services are essential to Agency mission performance and mission support management. NASA's IT strategy calls for the ability to support current and future missions, both reliably and affordably, with an increasingly flexible, mobile workforce. The OCIO will continue to consolidate legacy contracts and data centers and increase the use of cloud computing. These efforts will generate cost savings through economies of scale while simultaneously improving the integration, goal alignment, security, oversight, and accountability across NASA's enterprise IT service providers. As part of OCIO's continuous enterprise improvement cycle, design and management of NASA's enterprise architecture will provide the roadmap and tools to navigate from IT strategy through execution and maintenance while enabling a consistent methodology for technology infusion and innovation.

NASA's Agency IT Services (AITS) Program provides enterprise applications that support NASA's business and information needs, with new initiatives and enhancements focused on improving business and management practices. The AITS Program also provides many common enterprise capabilities like integrated e-mail, calendaring, instant messaging, directory services, and the NASA public Web portal. The NASA IT strategy is to improve service delivery across a portfolio of enterprise IT assets by delivering integrated services that are increasingly driven by customer priorities and collaboration and scaled appropriately to achieve cost savings and delivery efficiencies.

### *Transitioning to an Enterprise-Based Approach for NASA IT*

The IT Infrastructure Integration Program (I3P) continues to be a key pillar in the ongoing transformation of NASA's core IT services from a Center-based model to an enterprise-based service provisioning and management model. The scope of I3P is broad and includes consolidation and central management of IT services in the areas of Tier 1 service desk and IT service ordering, web services development and management, enterprise business applications development and operations, integrated network/communications services, and end user services. I3P will result in more standardized, cost effective systems and services that will increase the Agency's ability to provide efficient IT services.

In FY 2011, NASA awarded contracts for major I3P service components: NASA Integrated Communications Services (NICS), which will provide Agency corporate and mission communication needs; Agency Consolidated End-user Services (ACES), which will provide NASA staff with personal computing services, mobile communications devices, and collaboration services; and the NASA Enterprise Applications contract to operate and maintain NASA's set of integrated enterprise business systems supporting all 10 NASA Centers, NASA Headquarters, and the NASA Shared Services Center.

### *Leveraging IT Innovation to Make NASA More Productive*

The OCIO also established a new position, the Chief Technology Officer (CTO) for IT, to work with industry and other Government organizations to identify innovative technology that can be quickly evaluated and introduced to NASA's scientists and engineers to improve their ability to conduct research and support NASA missions.

The Agency CTO identified CTOs at each Center and the Jet Propulsion Laboratory and established a set of virtual laboratories to solicit and evaluate proposals for innovative solutions to real world NASA issues. Some examples of proposals that were funded through the virtual laboratories in FY 2011 include the following:

- **Agency SharePoint 2010 My Site:** The laboratory will conduct a feasibility assessment of using 2010 My Site with SharePoint for Agency purposes. Using a working prototype, the project will test My Site's capability as a portal for user information across the Agency by aggregating various SharePoint infrastructure information, across the Agency through My Site. SharePoint is an online tool for information sharing and document collaboration using a browser interface. My Site is a personal site that gives users a central location to manage and store documents, content, links, and contacts. The prototype, if viable, has the potential to make it easier for employees to access their files offsite and to improve document sharing.
- **Collaboration Application Interoperability in the Cloud:** Cloud computing delivers computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility over a network like the Internet. This laboratory will evaluate hosted collaboration application solutions that centralize multiple Agency collaboration architecture functional requirements, initiate a repeatable process for application innovation/integration within the NASA architecture, and architect solutions for prototype development that integrate separately hosted cloud collaboration application environments.
- **Google Apps Pilot:** This collaborative laboratory will pilot Google Apps and prepare it for release as an Agency software as a service. Google works has been working with the U.S. government to create a dedicated, secure cloud computing system.
- **Paperless Conference Room Study:** The laboratory will evaluate the intuitiveness and effectiveness of using a tablet device to distribute presentations to meeting attendees on their tablets to eliminate the need for printing handouts. The goal is to investigate the feasibility of an integrated capability that allows easy configuration for presentation, intuitive ability for viewers to capture notes on the presentation and e-mail the presentation along with the notes to themselves, and the ability for the presenter to wipe the presentation and notes from the attached tablets on completion of presentation.

It is expected that through these early technology exploration activities, NASA can increase the productivity of its workforce and provide integrated information management to not only to its employees but also to the general public in a far more usable form.

## Developing and implementing long-term infrastructure plans

### *Creating a facilities Master Plan*

In the area of facilities management, NASA has undertaken a multi-pronged effort to integrate decision making across the Agency to arrive at long-term facilities solutions that preserve and provide the institutional resources needed to support NASA's mission. The first product from the implementation of the new strategy is an integrated Agency Master Plan.

The Agency-wide Master Plan conveys a comprehensive plan for facilities development and stewardship and will enable significant progress towards NASA's overall goal of a sustainable, right-sized infrastructure set aligned with mission requirements. The plan will allow NASA to leverage facility investments to manage strategic risks (e.g., deferred maintenance, the possible erosion of research capabilities through insufficient facilities and equipment, the impacts of climate change) and total cost of facilities ownership, particularly renewal and energy/operations costs. The plan includes a five- and 20-year Agency Capital Investment Program Plan and it compares benchmarks and projected progress against goals in the areas of readiness, size, and stewardship.

### *Reducing and recycling can make a big difference*

A key aspect of the new facilities strategy is reducing operating costs and eliminating inactive and obsolete facilities that are no longer required for NASA's Mission through its demolition program. Abandoned facilities pose a potential safety and environmental liability. These abandoned facilities still must be maintained at minimal levels to prevent increasing safety and environmental hazards, imposing a drain on limited maintenance dollars. Demolishing these abandoned facilities allows the Agency to avoid non-productive operating costs required to keep abandoned facilities safe and secure and reduce the liability associated with these facilities. During 2011, NASA initiated the facilities demolition process for five significant Agency facilities.

### *Demolishing for the future while remembering the past*

At Langley Research Center, two facilities—the 16 Foot Transonic and the Langley Full Scale Tunnels—are being taken down, piece by piece. They are victims of age and studies that say they are no longer needed for a number of reasons. Their demolition is part of Langley's ongoing repair-by-replacement strategy (called New Town) and revitalization to make the Center more efficient and better prepared for the future.

While the facilities may no longer be needed, they are leaving behind a notable history. The Langley Full Scale Tunnel, with its two propeller assemblies bigger than a three-story building and test section 30 feet wide by 60 feet long, was known worldwide for having hosted Orville Wright, Charles Lindbergh, and Howard Hughes, as well as testing hundreds of aircraft and spacecraft since it started operation in 1931.

Ultimately four tunnels are slated to come down as part of a NASA-wide effort to remove excess capability and reduce deferred maintenance costs. After the Langley Full Scale Tunnel work is finished, two smaller tunnels at Langley will come down: the 8-Foot Transonic Pressure Tunnel, which was closed in 1996, and the 8-Foot High Speed Tunnel, an historic landmark that was deactivated in 1956.

The tunnels are part of a $5.7 million demolition contract, but the actual cost of the project to the government will be $3.6 million, according to the Center Operations Directorate, because more than two million dollars worth of the materials, including steel and concrete, will be recycled.

Langley officials have worked hard to make sure all the tunnels' achievements have been properly documented in print and imagery and artifacts preserved in displays and museums. Some of the blades from the 16-Foot Tunnel have been incorporated into the first New Town building at Langley and parts of the other tunnels are slated to go to museums, including the Smithsonian Institution.

A member of the demolition crew stands in silhouette inside Langley's Full-Scale Tunnel. (Credit: NASA/S. Gibbs, G. Homich, S. Smith)

### *Saving water across NASA*

For 2011, NASA reported a potable water use intensity reduction of 9.8 percent from the Agency's baseline, exceeding the target of eight percent. NASA's Ames Research Center was recognized for implementing a water reuse project, winning the Federal Energy and Water Management's Water Conservation Small Group Award. Ames partnered with the City of Sunnyvale to reduce consumption of potable water and to use reclaimed water for landscape irrigation, construction site dust control, and washing aircraft. The Native Plant Initiative converts high maintenance, water-intensive turf/grass areas to low-maintenance, drought-tolerant native plants. The overall effort decreased Ames' potable water consumption by more than 80 million gallons and saved $400,000 annually. In addition to the Ames project, water conservation activities and projects were also implemented at Langley Research Center, Michoud Assembly Facility, and Stennis Space Center, resulting in an estimated total of $300,000 in annual savings and 127 million gallons in annual water savings.

## Outcome 5.2

Ensure vital assets are ready, available, and appropriately sized to conduct NASA's missions.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Through 2015, assure zero fatalities or permanent disabling injuries to the public. | | | | | 5.2.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Assure zero fatalities or permanent disabling injuries to the public resulting from NASA activities during the fiscal year. | None | None | None | 10SMS01 Green | AMO-11-9 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, achieve a four percent reduction in the total case rate and lost time rate for the NASA civil service work force. | | | | | 5.2.1.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Reduce Total Case Rate and Lost Time Case Rate by one percent, in accordance with the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative. | None | None | None | None | AMO-11-10 Red |
| ***Why NASA rated APG AMO-11-10 Red:*** At year-end, NASA was about 2 times lower (better) than the President's Protecting our Workers & Ensuring Reemployment (POWER) goal for TCR and 5 times lower (better) than the POWER goal for LTCR. However, NASA undertook a stretch goal of lowering the Agency's already low rates by 1 percent, from the POWER baseline goal year (FY 2009). The data for this calculation is current through the third quarter (fourth quarter data is not available until December), with end-of-year projections by the Department of Labor's Office of Workers' Compensation Programs, who must validate and accept these cases, that place NASA at small upswings in both TCR and LTCR from the FY 2009 base year (thus missing the 1 pecent internal goal). Even with the slight upswings, NASA still remains one of the best in the government, and still signifcantly below (better than) the POWER goals. (See page 161 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, reduce damage to NASA assets by eight percent from the 2010 baseline. | | | | | 5.2.1.3 Red |
| ***Why NASA rated Performance Goal 5.2.1.3 Red:*** NASA does not anticipate meeting this performance goal by 2015, due to the Glory launch vehicle mishap in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, irrespective of no damage beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals, that also feed this performance goal. (See page 161 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Reduce damage to NASA assets by two percent per fiscal year, based on a five-year running average. | None | None | None | 10SMS03 Green | AMO-11-11 Red |
| ***Why NASA rated APG AMO-11-11 Red:*** This annual performance goal will not be met in FY 2011, due to the loss of the Glory mission. Based on the magnitude of the cost of the loss of the Glory mission, FY 2011 will see a growth from FY 2010, rather than a reduction. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2014, consolidate and centralize the management of information technology (IT) enterprise services for end user services, communications, enterprise applications, enterprise data centers and web services. | | | | | 5.2.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Achieve Initial Operating Capability (IOC) for five Service Offices (Web Services, Communications, Enterprise Service Desk, End User Services, and NASA Enterprise Applications) as part of the NASA Information Technology Infrastructure Integration Program (I3P). | None | None | None | 10IT02 Green | AMO-11-12 Yellow |
| ***Why NASA rated APG AMO-11-12 Yellow:*** Four of the five planned service offices achieved Initial Operating Capability (IOC). The End User Services (ACES), Enterprise Applications (EAST), Enterprise Service Desk (ESD), and Communications (NICS–Networking) services all have their office structures in place, are managing the transition to these new services, and continue to operate the current services. The one service office that did not reach IOC in FY 2011 is the one for the Web services (WEST). The implementation of this initiative has been delayed to resolve some issues with the contract award. NASA remains on track for the consolidation and centralization of these services and capabilities by 2014. (See page 174 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, implement a capability to identify and prevent unauthorized intrusions on the NASA institutional and mission networks. | | | | | 5.2.2.2 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Implement intrusion detection sensors monitored by the NASA Security Operations Center (SOC) on 75 percent of NASA institutional network monitoring sites. | None | None | None | 10IT06 Red | AMO-11-13 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2014, decommission the Agency Administrative mainframe computer. | | | | | 5.2.2.3 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Implement, in the SAP environment, the replacement for the mainframe-based NASA Supply Management System. | None | None | None | None | AMO-11-14 Green |
| **FY 2011 Performance Goal** | | | | | |
| By 2015, reduce data center energy consumption by 30 percent. | | | | | 5.2.2.4 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Develop a data center consolidation plan for NASA that includes an enterprise assessment of NASA's data center footprint. | None | None | None | None | AMO-11-15 Green |
| **FY 2011 Performance Goal** | | | | | |
| By 2015, establish at least four innovation laboratories that provide more effective, efficient, and responsive information technology (IT) across NASA in support of the Agency's Mission. | | | | | 5.2.2.5 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Implement a Core Information Technology (IT) Innovation Laboratory infrastructure to support experimental technology incubation activities in areas ranging from communications, information dissemination, and collaboration application interoperability in a cloud environment. | None | None | None | None | AMO-11-16 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Consolidate functions and offices to reduce real property need, and use Agency Integrated Master Plan to identify and dispose of excess and aged facilities beyond useful life. | | | | | 5.2.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Finalize 8 of 10 Center Master Plans and incorporate into the Agency Integrated Master Plan. | None | None | None | 10FAC01 Green | AMO-11-17 Green |
| Initiate facilities demolition process for five significant Agency facilities. | None | None | None | None | COF-11-1 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| HPPG: Conserve valuable natural resources by reducing NASA's energy and water use. | | | | | 5.2.3.2 Yellow |
| ***Why NASA rated Performance Goal 5.2.3.2 Yellow:*** Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA expects to exceed its targets on the measures related to water use and fleet management, but fall short on the energy intensity goals. See rating explanation for ECR-11-1 for more detailed information on the energy intensity measure. (See page 159 for the Performance Improvement Plan.) | | | | | |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Reduce energy intensity use annually by three percent from an FY 2003 baseline. | None | None | None | 10FAC04 Red | ECR-11-1 Red |
| ***Why NASA rated APG ECR-11-1 Red:*** Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA reduced energy intensity by an estimated 1 percent, for an 8 percent reduction from 2003 baseline. The FY 2011 goal was 18 percent from the 2003 baseline and NASA expects to reduce energy intensity by 10 percent (+/- 2 percent) in that same timeframe. Recent NASA topline budget reductions lowered funding planned for specific energy efficiency measures and new building construction, restoration, and rehabilitation, negatively impacting NASA's energy conservation program and reducing chances of meeting Federal requirements. Despite the reduced funding, NASA continues to work to reduce energy intensity, and during FY 2010–FY 2011, the Agency completed construction and received LEED certification for 12 new buildings (1 Certified, 2 Silver, 6 Gold, and 3 Platinum). Three completed buildings are under review for certification (2 Silver and 1 Gold), and ten more buildings are under construction seeking LEED certification of Silver or Gold level in FY 2012. Eleven buildings are in the design phase for Silver or Gold LEED level. (See page 159 for the Performance Improvement Plan.) | | | | | |
| Reduce potable water use annually by two percent from an FY 2007 baseline. | None | None | None | 10FAC06 Green | ECR-11-2 Green |
| Reduce fleet vehicle energy use annually by two percent of petroleum products from an FY 2005 baseline. | None | None | None | 10FAC05 Green | ECR-11-3 Green |
| | | | | | |
| | | | | | |
| **Uniform and Efficiency Measures** | | | | | |
| | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Maintain system execution time during the year-end close process at FY 2010 baseline. | None | 8IEM07 Red | 9IEM9 Red | 10IT12 Green | AMO-11-23 Green |
| | | | | | |

# Outcome 5.3

## Ensure the availability to the Nation of NASA-owned strategically important test capabilities.

NASA is responsible for stewardship of space and aeronautical laboratory systems, facilities, core competencies, and engineering and research capabilities. The Rocket Propulsion Test (RPT) Program within the Human Exploration and Operations (HEO) Mission Directorate, the Aeronautics Test Program (ATP) within the Aeronautics Research Mission Directorate, and the Strategic Capabilities Assets Program (SCAP) within the Office of Strategic Infrastructure ensure that these assets and capabilities are available to serve current and future needs of the Agency and the Nation. Assets and facilities managed and maintained by these programs—many of which are unique within the United States—are available to other government agencies and the commercial sector for developing and testing their technologies.

RPT optimizes use of NASA's rocket propulsion test assets for efficiency and cost effectiveness and ensures that a minimum core capability for all aspects of rocket propulsion testing is maintained. These capabilities are critical to ensuring the Nation's access to space by: providing engine, component, systems and anomaly testing; encouraging the pursuit of partnerships with the emerging commercial space sector; supporting Agency programs relative to the utilization of RPT resources; and investing in test technology and maintenance strategies.

ATP corporately manages and ensures the strategic availability of a minimum, critical suite of aeronautical test facilities (like wind tunnels), support aircraft, laboratories, and the western aeronautical test range, necessary to meet the long-term aeronautical test requirements for the Nation.

SCAP identifies, prioritizes, and manages Agency key assets and capabilities that are essential to the future needs of NASA and/or the Nation, including some capabilities that lack an adequate business base. This function ensures that key assets and capabilities, as elements of the Agency's physical and intellectual infrastructure, are available to perform the Agency's Mission. They perform an Agency cross-cutting function that encompasses assets and capabilities that may be used across multiple mission directorates and program areas.

Maryland Senator Barbara Mikulski and NASA Administrator Charles Bolden cut the ribbon at the new Horizontal Integration Facility (HIF) at NASA's Wallops Flight Facility, Wallops Island, Virginia. The HIF will support medium-class mission capabilities. The first customer to use the facility will be Orbital Sciences Corporation with its Taurus II launch vehicle. Wallops is managed by the Goddard Space Flight Center in Maryland. (Credit: NASA)

### Meeting NASA, Department of Defense, and commercial rocket propulsion testing capabilities and requirements

Maintaining the Nation's access to space requires continuous investment in development, evolution, and maturation of propulsion technologies, as well as qualification testing of flight propulsion systems. RPT optimizes use of NASA's rocket propulsion test assets for efficiency and cost effectiveness and to ensure a minimum core capability for all aspects of rocket propulsion testing is maintained. RPT provides engine, component, systems, and anomaly testing, encourages the pursuit of partnerships with the emerging commercial space sector, supports Agency programs relative to the utilization of RPT resources, and invests in test technology and maintenance strategies.

### Providing aeronautics test facilities to meet the needs of NASA and national aerospace programs

The Aeronautics Test Program (ATP) is designed to corporately manage and ensure the strategic availability of a minimum critical suite of aeronautical test facilities which are necessary in meeting the long-term aeronautical test requirements for the Nation. ATP is comprised of two projects to support the goals noted:

The J2-X engine 10001 being developed for NASA's Space Launch System recently completed its sixth test firing on September 28, 2011, at the Stennis Space Center A-2 test stand. NASA met all its FY 2011 goals, including the 40 second run time at a power level of 99 percent. Until 2009, RPT used the A-2 test stand to test Space Shuttle engines. After a decommissioning period, Stennis employees spent 10 months converting the stand to the parameters needed to test engines for NASA's new engine series. NASA conducted a facility readiness review on the A-2 test stand in mid-March and found that all the major modifications were complete and the test stand was ready to begin testing the J-2X engine. (Credit: NASA)

- The Aeronautics ground test facilities consist of various categories of wind tunnels located at Ames Research Center, Glenn Research Center, and Langley Research Center.
- The flight operations and test infrastructure are located at the Dryden Flight Research Center and include the western aeronautical test range, support aircraft, testbed aircraft, simulation and flight landing loads laboratories.

### *ATP upgrades wind tunnels*

Strategic initiatives accomplished by ATP in FY 2011 include investments and upgrades at five major wind tunnels across its portfolio to provide new capability and improved facility reliability and investments in flight assets to enable a new flight research capability. Included in ATP investments are a new acoustic measurement capability at the 14 x 22 Foot tunnel at Langley Research Center, a new engine icing test capability at the Propulsion Systems Laboratory at Glenn Research Center, and a modified research aircraft to enable Aeronautics Research Mission Directorate flight testing at the Dryden Flight Research Center. ATP investments also led to development and implementation of new and improved test technologies to increase productivity and efficiency and improve research data quality, including investments in the National Force Measurement Technology Capability.

### *Good decisions start with the right tool*

Also in FY 2011, ATP finalized a Capability Reliance Framework, a top-level decision analysis instrument that provides a view of the entire suite of ATP ground test capabilities and includes similar test assets owned and operated by the Department of Defense. This decision analysis tool will inform decision makers about capability needs, which facilities and resources operated by NASA and other entities could serve those needs, reliance opportunities, condition and lifecycle costs, and other related issues.

| **Outcome 5.3** | | | | | |
|---|---|---|---|---|---|
| Ensure the availability to the Nation of NASA-owned, strategically important test capabilities. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Develop and execute the Rocket Propulsion Test (RPT) Master Plan. | | | | | **5.3.1.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Release the Rocket Propulsion Test (RPT) Master Plan. | **None** | **None** | **9SFS4 Yellow** | **10SFS09 Yellow** | **SFS-11-1 Green** |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Ensure that testing capabilities are available in order to support the research, development, test and engineering milestones of NASA and Department of Defense (DoD) programs. | | | | | **5.3.2.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Achieve ratings greater than 86 percent for overall quality and timeliness of Aeronautics Test Program (ATP) facility operations. | **None** | **None** | **None** | **10AT11 Green** | **AR-11-11 Green** |

# Outcome 5.4

## Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.

Both human and robotic space exploration require an efficient and reliable infrastructure of assets, facilities, and services to keep operations running smoothly. These include access to launch vehicles, launch and range complexes, and a communication network to receive and transmit data.

The Launch Services Program (LSP) is responsible for understanding the full range of civil space launch needs. They work closely with other government agencies and the launch industry to make available the safest, most reliable, on-time, and cost-effective commercial launch opportunities over a wide range of launch systems. LSP personnel work with customers from universities, industry, government agencies, and international organizations from the earliest phase of mission planning to purchase of fixed-price launch services from domestic suppliers. LSP personnel also seek opportunities to share unused payload capacity aboard non-NASA launches to leverage launch funds. Most importantly, they provide oversight to help NASA's valuable, one-of-a-kind missions achieve their space flight objectives.

The Human Exploration and Operations (HEO) Mission Directorate and the Kennedy Space Center have been working to prepare the Center for future government and commercial space exploration by transitioning, refurbishing, and upgrading facilities. This includes launch pads and the launch control center.

Space Communications and Navigation (SCaN) coordinates multiple space communications networks, as well as network support functions to regulate, maintain, and expand NASA's space communications and navigation capabilities in support of all NASA's space missions. These networks include satellites that relay data from mission spacecraft to the ground and ground assets and facilities. SCaN reviews national and international data standards with the aim to keep systems compatible and reviews the Agency's technology needs to keep the systems efficient, reliable, and cost-effective. They also are developing a communication and navigation architecture to serve NASA's needs through 2030.

SCaN completed some key milestones for its development projects during FY 2011.

- The Space Network Ground Segment Sustainment project completed its System Requirements Review (SRR). The goal of the project is to implement a flexible and extensible ground segment that will allow the Space Network to maintain the high level of service in the future and accommodate new users and capabilities, while reducing the effort required to operate and maintain the system. The SRR examines the functional and performance requirements defined for the system and the preliminary project plan and ensures that the requirements and the selected concept will satisfy the needs of the Space Network.
- The Tracking and Data Relay Satellite (TDRS) project completed System Integration Review (SIR) for the TDRS K satellite, which will become part of the space segment of the Space Network. The SIR evaluates the readiness of the project to start flight system assembly, test, and launch operations.

### Ensuring reliable and cost-effective access to space

#### *Successes tempered by a loss*

The Launch Services Program (LSP) managed the launches of four NASA missions in FY 2011. LSP launched NASA's Aquarius instrument aboard the Space Agency of Argentina (Comisión Nacional de Actividades Espaciales) SAC-D spacecraft into low Earth orbit on June 10, and sent Juno toward Jupiter on August 5. The Gravity Recovery and Interior Laboratory (GRAIL) mission, designed to increase knowledge of Earth's Moon, launched on September 10. Unfortunately, the March 9 launch of the Glory mission was unsuccessful and the spacecraft was lost. Upon completion of the Mishap Investigation Board, NASA will develop and execute a corrective action plan.

#### *Working to expand the selection of launch vehicle providers*

Working across the launch vehicle industry, LSP is supporting the emergence of a U.S. commercial space sector by providing competitive opportunities to U.S. commercial launch providers. In FY 2011, LSP executed a procurement that allows new providers to be added and existing providers to "on-ramp" additional launch vehicles to an existing contract.

### *NASA, NRO, USAF establish strategy for certifying new expendable launch vehicles*

Just after the end of the fiscal year, NASA, the U.S. Air Force, and the National Reconnaissance Office (NRO) signed an agreement to establish clear criteria for certification of commercial providers of launch vehicles used for national security space and civil space missions.

The U.S. government is committed to procuring commercial launch services for its satellite and robotic missions, including evolved expendable launch vehicle (EELV) launches. The new entrant launch vehicle certification strategy is the latest step in a cooperative effort by the three agencies to take advantage of new launch capability for their missions.

The agencies previously signed a Letter of Intent in October 2010, signaling their collaboration on launch requirements. They signed a Memorandum of Understanding in March, outlining their plans for future EELV-class launch vehicle acquisition, including the need for a coordinated strategy for certification of new entrant launch systems.

The basis of the new strategy comes from NASA's existing policy directive for launch vehicle risk mitigation. It also recognizes that mission-unique requirements from each of the three agencies may result in different certification approaches to mitigate launch risk. The document provides a common framework and language among the agencies for communicating expectations to new launch service providers.

The risk-based certification framework allows the agencies to consider both the cost and risk tolerance of the payload and their confidence in the launch vehicle. For payloads with higher risk tolerance, the agencies may consider use of launch vehicles with a higher risk category rating and provide an opportunity for new commercial providers to gain experience launching government payloads.

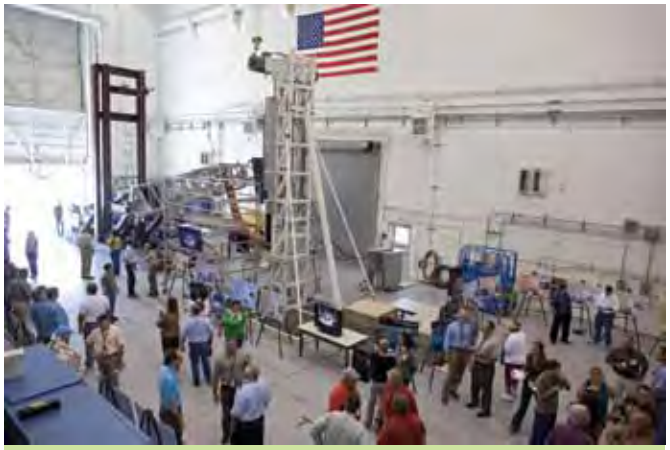
Within a given risk category rating, if new entrants have launch vehicles with a demonstrated successful flight history, then the government may require less technical evaluation for non-recurring certification of the new launch system. This new strategy further enables competition from emerging, commercially developed launch capabilities for future Air Force, NASA, and NRO missions.

## Building the Florida launch and range complex of the future

### *Launch equipment test facility is ready for new business*

Kennedy Space Center's Launch Equipment Test Facility, or LETF, is an engineer's paradise, featuring fixtures capable of simulating launch conditions, a machine shop and a welding facility, and a new vehicle motion simulator, which simulates all of the movements a vehicle could experience from rollout to launch.

Since 1977, LETF has supported NASA's Launch Services, Space Shuttle, International Space Station, and exploration programs, as well as commercial providers. NASA recently completed a four-year, $35 million comprehensive upgrade to make sure the testing ground remains at the top of the support system testing pyramid.



Workers learn about the LETF's capabilities in its 6,000-square-foot high bay. (Credit: NASA/D. Gerondidakis)

### *Launch Pad 39B retooled for future*

Launch Pad 39B at NASA's Kennedy Space Center in Florida recently made way for a new generation of rockets when workers took down the gantry that stood in support of Space Shuttles for 30 years. Whatever rocket heads out to the pad in the future, it's going to bring its support structure with it. With that in mind, the future Pad B will provide all the fluids, electrical, and communications services to the launch platform.

NASA plans to use the Mobile Launcher, or ML, to carry the new Space Launch System rocket to the pad and possibly use one of the Mobile Launcher Platforms, or MLP, for commercial vehicles. Construction will start soon to build two electric elevators, sized to reach all levels of the ML and MLP, at the pad to replace the aged one there now.

The flame trench at Launch Pad 39B, which is currently lined with fireproof bricks and concrete, will be refurbished and the flame deflector in the middle could become portable to handle future rockets of different sizes. NASA used a moveable flame trench during Apollo. (Credit: NASA/J. Grossmann)

Along with the dramatic changes on top of the pad that removed the Shuttle structures, there is a considerable amount of refurbishment under way inside the launch pad perimeter. NASA already has removed a million feet of cables, the storage tanks for hypergolic fuels, and the corrosive chemicals that powered the Shuttle's thrusters in space. Instrumentation that monitors and controls the facility and ground systems, as well as the communications systems, has been replaced with new state-of-the-art equipment. NASA also has installed a new weather instrumentation system at the pad that monitors meteorological conditions and detects lightning.

NASA is fixing and sealing chipped and damaged concrete pedestals supporting propellant lines running from storage tanks to the pad's surface so they can handle at least 25 more years beside the ocean. The huge white spheres that held liquid hydrogen and liquid oxygen have been emptied, too. They will be repainted, but not taken down. The old liquid oxygen water-cooled vaporizer will be replaced with modern, air-cooled one that is far more efficient than the water-cooled system used the past 30 years.

## Expanding and improving communications and navigation services for current and future missions

In FY 2011, SCaN maintained at least 99 percent proficiency of all of its networks, providing communication and navigation services to 29 spacecraft using the Deep Space Network, 35 spacecraft using the Space Network, and 33 spacecraft using the Near Earth Network. The Near Earth Network also provided communication and navigation services to 33 launches during launch and early orbit phases.

The Deep Space Network is an international network of antennas that supports interplanetary spacecraft missions and radio and radar astronomy observations for the exploration of the solar system and the universe. The network also supports selected Earth-orbiting missions. The Space Network consists of a space segment, composed of the Tracking and Data Relay Satellite System, and a ground segment, which includes the White Sands Complex and the Guam Remote Ground Terminal. Data from the satellites is downlinked to the ground segment. The Near Earth Network provides tracking, telemetry, and communications services, using antenna assets located around the world, for orbital missions and occasionally suborbital missions.

SCaN continued the sustaining and engineering of its aging networks, including completion of upgrades to the Near Earth Network assets at McMurdo Ground Station in Antarctica. The Deep Space Network Aperture Enhancement project broke ground for adding 34-meter (110.5 foot) antennas at the Canberra Deep Space Communications Complex in Canberra, Australia. The program also made significant progress in technology development. The Communication, Navigation and Networking re-Configurable Testbed (CoNNeCT) made significant progress and was readied for System Acceptance Review in early FY 2012.

## Outcome 5.4

Implement and provide space communications and launch capabilities responsive to existing and future science and space exploration missions.

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches. | 5.4.1.1 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Sustain 100 percent success rate with the successful launch of NASA-managed expendable launches as identified on the Launch Services Flight Planning Board manifest. | None | None | None | 10SFS11 Green | SFS-11-2 Yellow |

***Why NASA rated APG SFS-11-2 Yellow:*** This annual performance goal was not met due to the loss of the Glory mission. NASA's Glory satellite did not reach orbit after its liftoff on March 4, 2011, due to a launch vehicle mishap. The Launch Services Program successfully launched the other three missions scheduled for this fiscal year. Aquarius successfully launched aboard a Delta II launch vehicle on June 10, 2011 from Vandenberg Air Force Base, CA. The Juno mission launched aboard an Atlas V rocket on August 5, 2011, from Cape Canaveral Air Force Station, FL. And lastly, the GRAIL mission launched aboard a Delta II Heavy launch vehicle on September 10, 2011. (See page 163 for the Performance Improvement Plan.)

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Continue utilizing existing contract mechanisms and agreements with emerging launch vehicle providers to gain information for future Launch Service orders and to provide technical exchanges to enhance early launch success. | 5.4.1.2 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Develop processes for space transportation partner information sharing between NASA's Launch Services Program (LSP), Exploration Systems Mission Directorate (ESMD), ISS, and other government customers, including but not limited to Department of Defense (DoD). | None | None | None | 10SFS10 Green | SFS-11-3 Green |

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| By FY 2014, enable future government and commercial launching and testing from the Florida launch and range complex. | 5.4.2.1 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Develop a 21st Century Space Launch Complex (21st CSLC) plan. | None | None | None | None | SFS-11-4 Yellow |

***Why NASA rated APG SFS-11-4 Yellow:*** This annual performance goal was not met due to a revision on the originally planned schedule for this activity. As is typical with NASA programs and projects in the formulation phase, schedules are expected to change as they are refined heading toward the development phase. As the fiscal year progressed, the maturity of the Human Exploration Capabilities programs increased, and NASA began to work through the significant milestones and associated product development and has settled on the current schedule. Under this schedule, NASA expects that this activity will be completed in the first quarter of FY 2012. (See page 169 for the Performance Improvement Plan.)

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| By 2014, launch two functionally identical Tracking and Data Relay Satellite (TDRS) spacecraft in geosynchronous orbits to replenish the Tracking and Data Relay Satellite System (TDRSS) constellation. | 5.4.3.1 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Complete Tracking and Data Relay Satellite (TDRS) K Payload and Bus Integration and test. | None | None | 9SFS6 Green | 10SFS07 Yellow | SFS-11-5 Green |

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| By FY 2016, replace or upgrade obsolete and unsustainable systems of the TDRSS Ground Segment at the White Sands Complex (WSC). | 5.4.3.2 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Complete the Space Network Ground Support Sustainment (SGSS) Integrated Baseline Review (IBR) and Systems Requirements Review (SRR). | None | None | None | 10SFS08 Yellow | SFS-11-6 Green |

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| By FY 2018, replace aging and obsolete Deep Space Network (DSN) 70-meter antenna at Canberra Deep Space Communications Complex (CDSCC). | 5.4.3.3 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Complete Deep Space Station-35 (DSS-35) Pedestal Excavation at Canberra Deep Space Communications Complex (CDSCC). | None | None | None | None | SFS-11-7 Green |

# Outcome 5.5

## Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success.

Strategic partnerships with the U.S. government and academic, industrial, and international organizations help NASA leverage resources, increase the impact of activities, and execute missions more effectively and efficiently. NASA works cooperatively with these partners to identify common goals, develop new technologies and applications, and share technical expertise to minimize risk. The Office of International and Interagency Relations (OIIR) provides executive leadership and coordination for all international partnerships. OIIR serves as the principal Agency liaison with the National Security Council, the Office of Science and Technology Policy, the Department of State, and the Department of Defense. OIIR also directs NASA's international relations, negotiates cooperative and reimbursable agreements with foreign space partners, provides management oversight and staff support of NASA's advisory committees, commissions, and panels, and manages the NASA Export Control Program and foreign travel by NASA employees.

To achieve this outcome, NASA is using mechanisms like building public–private partnerships, hosting government capabilities on commercial spacecraft, and purchasing scientific or operational data products from commercial satellites. The ability to procure technology or services competitively when needed, rather than maintain a capability that may not be fully used, allows NASA to focus resources for institutional and program capabilities in areas of evolving strategic importance.

### Using the ISS as a National Laboratory for research, technology development, and education

#### *NASA awards CASIS management of ISS National Laboratory Research*

NASA issued a Cooperative Agreement Notice on February 14, 2011, to seek a management partner for the portion of the International Space Station (ISS) that was designated a National Laboratory in 2005. The NASA Authorization Act of 2010, which extended ISS operations until at least 2020, also directed the Agency to establish this organization.

On August 31, NASA finalized a Cooperative Agreement with the Center for the Advancement of Science in Space (CASIS) to manage the portion of the International Space Station that operates as a U.S. National Laboratory. The ISS Program will continue its focus on maintaining the ISS, coordinating available crewmember time, and delivering critical services like power and data relay that researchers need to conduct their experiments.

CASIS, the independent, nonprofit research management organization, will be located at the Kennedy Space Center, and will help ensure the ISS' unique capabilities are available to the broadest possible cross-section of U.S. scientific, technological and industrial communities.

CASIS will develop and manage a diversified research and development portfolio based on U.S. national needs for basic and applied research; establish a marketplace to facilitate matching research pathways with qualified funding sources; and stimulate interest in using the National Laboratory for research and technology demonstrations and as a platform for science, technology, engineering, and mathematics education. The goal is to support, promote, and accelerate innovations and new discoveries in science, engineering, and technology that will improve life on Earth.

### Leveraging international and interagency partnerships

#### *OIIR keeps NASA well-connected*

NASA has continued to establish international and interagency partnerships to both inform and encourage broad support for NASA's planned mission activities.

NASA continued the management of 520 active international agreements with over 125 countries, which included the establishment of 106 new international agreements or extensions this year. In addition, the Agency continued the management of over 200 interagency agreements including the establishment of 40 new interagency agreements this year. NASA is directing ongoing efforts to improve coordination of the more than 800 active interagency agreements that currently exist Agency-wide. On September 22, the International Space Exploration Coordination Group (ISECG) released

the Global Exploration Roadmap (GER). This document was developed with inputs from all of the participating agencies. The GER reflects an international effort to define feasible and sustainable exploration pathways to a variety of destinations. This first iteration of the GER is intended to inform and help focus the planning currently underway in each of the partner agencies in the areas of planetary robotic exploration, advanced technology development and use of the ISS in preparation for exploration. The GER has been posted to the ISECG Web site (https://www.globalspaceexploration.org/home) and the NASA Web site (http://www.nasa.gov/exploration/about/isecg/).

| Outcome 5.5 | | | | | |
|---|---|---|---|---|---|
| Establish partnerships, including innovative arrangements, with commercial, international, and other government entities to maximize mission success. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| HPPG: Establish an independent non-profit organization (NPO) to enhance the utilization of the ISS as a National Laboratory. | | | | | **5.5.1.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Transition management of the ISS U.S. National Lab for non-NASA research to the non-profit organization (NPO). | **None** | **None** | **None** | **None** | **ISS-11-6 Green** |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Actively engage and provide leadership in international and interagency forums. | | | | | **5.5.2.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Complete the International Space Exploration Coordination Group (ISECG) roadmap to identify common interests among international space agencies in human and robotic exploration of the solar system. | **None** | **None** | **None** | **None** | **AMO-11-18 Green** |

# Share NASA with the public, educators, and students to provide opportunities to participate in our Mission, foster innovation and contribute to a strong national economy.

NASA's priority is to make information from missions, research, and discoveries available for the benefit of the Nation. In its 2011 Strategic Plan, NASA emphasized this priority by creating a new strategic goal dedicated to education, public outreach, and transparency. The Agency has two organizations focused on achieving this strategic goal.

The Office of Education (Education) stimulates student interest and achievement in science, technology, engineering, and mathematics (STEM) fields through the excitement of NASA's missions and activities. STEM-focused teachers combine their skills with NASA education products to motivate student achievement and spur creative and critical thinking both in and out of the classroom. These students will become the Nation's future STEM workforce, tackling technical and scientific challenges to improve quality of life.

The Office of Communications (Communications) shares NASA's message and information with a broad audience and encourages active participation. Traditional means like print, television, and live events continue to be a mainstay of connecting with the public. However, Communications also has adopted emerging technologies and media that allow greater access and participation by the public, students, and teachers, including virtual events, live streaming video, online chats, and social media.

On August 17, 2011, the crew of STS-135, NASA's final Space Shuttle mission, and Sesame Street's Elmo welcomed visitors to "What's Your Favorite Space?" in New York City. For the free public event, co-presenters NASA and Eventi transformed an outdoor plaza into a miniature space outpost filled with displays, including an inflatable Mars rover, demonstrations, interactive exhibits, video segments, children's activities, and more. Pictured with Elmo is STS-135 Commander Chris Ferguson. (Credit: NASA/S. Smith)

## Benefits

NASA Education offers structured programs for students and educators to engage in STEM learning activities. These include competing in technical design challenges, launching student-built payloads, and participating in research and hands-on engineering experiences. Some students get the opportunity to work with real-world research platforms like high-altitude balloons, sounding rockets, aircraft, and space satellites. Undergraduate and graduate students can contribute directly to NASA's missions by working with scientists and engineers on their research and technology development programs while gaining valuable experience. Workshops, courses, and grant awards help teachers use NASA themes and materials to inspire their students in STEM topics.

NASA is actively planning for the workforce of tomorrow. Education coordinates with NASA's Offices of Human Capital Management and Diversity and Equal Opportunity to ensure that NASA's portfolio of education investments align with the long-term needs of the Agency. This includes supporting internships and fellowships at the Centers to inspire students at all levels to pursue STEM-related careers vital to NASA's and the Nation's future.

Communications delivers beneficial services that span public outreach and relations, messaging, and history. These services keep the public aware of the Agency's latest activities and achievements. A public that is knowledgeable and interested in science, aeronautics, and exploration will value the impact of advances in these fields that help maintain global competitiveness and a robust economy.

The Agency's online presence also has become an essential tool for fostering transparency in operations and management practices. NASA strives to increase the amount of information—and speed at which it is available—to provide insight into the Agency's performance and stewardship of taxpayer dollars.

## Risks to Achieving Strategic Goal 6

**Attracting and Retaining Students in STEM.** With the myriad of opportunities that compete for students' attention, NASA's challenge is to ignite a passion for science, technology, engineering and math. Part of this challenge is in reaching students, and the people who most influence them, with products and services that will attract learners at all levels to STEM careers. NASA Education uses the exciting content and results from NASA missions to develop products and services that support students, educators, and national STEM initiatives. Through these resources, NASA Education fosters development of public–private partnerships—collaborations that build communities to support STEM education and provide stability through times of economic decline. NASA Education works cooperatively with universities, professional education societies, national and state-based organizations, and school districts to ensure that NASA products and services continue to meet the evolving needs of formal and informal educators and students, both in and out of the classroom. Education seeks opportunities for early adoption of tools and techniques shown by research to positively impact teaching, learning, and interest in STEM topics.

**Reaching New Audiences.** There are more channels for communication and public engagement than ever before. Understanding the character of newer generations and their preferred communication modes, styles, and technologies will help NASA communicate its value. As an organization known for research and technology, NASA embraces new tools and works to keep pace with new technology. The Office of Communications must balance use of new and traditional media tools as the Agency strives to communicate across all sections of the public.

During FY 2011, NASA Education completed a key milestone for Strategic Goal 6:

- The 12 member Education Design Team completed the NASA Education Recommendation Report, an evaluation of NASA's education program in the context of current education trends requested by Administrator Charles Bolden and Deputy Administrator Lori Garver. Based on the Education Design Team's recommendations, Education will create a tightly focused portfolio of projects that fit within its Education Framework. (Read the complete report.)

# Outcome 6.1

## Improve retention of students in STEM disciplines by providing opportunities and activities along the education pipeline.

A critical part of NASA's Mission is to inspire the next generation of explorers so that the Nation's preeminence in space exploration, aeronautics, and science can continue into the future. NASA educational tools are designed to capture student interest, nurture their natural curiosities, and excite their minds. By providing hands-on opportunities to students of all ages and their educators, and engaging them in simulations and authentic research, NASA stimulates creativity and encourages the growth of a new generation of scientists and engineers.

Many of NASA's grant recipients are university and college science, technology, engineering, and mathematics (STEM) programs. NASA Education and Office of Diversity and Equal Opportunity (ODEO) partner to realize the goals of equal opportunity requirements among STEM and related programs receiving NASA financial assistance, including grants for education and training. Under laws prohibiting discrimination in federally funded programs, like Title VI of the Civil Rights Act of 1964 and Title IX of the Education Amendments Act of 1972, ODEO conducts compliance and enforcement activities to ensure that these programs afford equal opportunities to their beneficiaries, regardless of race, color, national origin, gender, age, or disability, and that the programs are free of discrimination and harassment. NASA Education and ODEO also review the equal opportunity technical assistance given to STEM programs. Equal opportunity technical assistance provides recipient programs more effective tools for conducting and measuring the success of targeted diversity outreach and recruitment efforts. The goal of technical assistance also is to achieve and maintain STEM program environments that are welcoming to more broadly diverse student bodies, ensuring greater diversity participation and retention in such programs.

Below are some of the activities that contributed to this outcome this fiscal year.

### *Providing students and educators with quality STEM curricular support resources and materials*

The first major step to retaining students in STEM disciplines is ensuring that they have access to quality, exciting STEM opportunities, resources, and materials throughout their education. As part of this objective, NASA Education offers a variety of programs to help K–12, undergraduate, and graduate educators better use NASA resources and improve their knowledge and skills. In FY 2011, 67,245 educators participated in NASA education programs. When combined with the 27,674 faculty members who participated in NASA's national higher education programs, the Agency has successfully reached 94,919 educators along the full length of the education pipeline. Additionally, 36,312 undergraduate and graduate students and 863,879 elementary and secondary students participated in NASA education opportunities.

### *Helping Education grant recipients serve a diverse student body*

NASA's program for reviewing civil rights compliance among its grantee institutions, such as universities and science centers, completed five institutional reviews. ODEO provided civil rights findings and recommendations to assist the institutions in enhancing their equal opportunity related efforts. Recommendations included targeted recruitment and environmental enhancements to attract and retain more diverse student bodies and appropriate signage and other program accessibility enhancements for individuals with disabilities and limited English proficiency.

### *NASA helps kick off FIRST Robotics Competitions in 2011*

NASA, the largest sponsor of the FIRST Robotics Competition, joined local, New Hampshire technology firms to launch this year's competitions at an event at Southern New Hampshire University in Manchester in January 2011.

FIRST, or For Inspiration and Recognition of Science and Technology, is a long-standing, international challenge to inspire curiosity and create interest in STEM among high school students. The event gives students the opportunity to design, build, test, and compete a robot that can perform specific functions. FIRST also gives students a crucial mentoring experience with NASA professionals, who help them explore solutions to robotics problems and understand real-world challenges faced by engineers and researchers.

NASA plays a significant role by providing public access to robotics programs to encourage young people to investigate careers in the sciences and engineering. Through the NASA Robotics Alliance Project, the Agency provides grants for 297 teams and sponsors four regional student competitions, including a new FIRST regional competition in Washington, DC, for 2011. NASA engineers and scientists participate with many of these teams as technical participants and mentors to the students. Through these mentoring activities, NASA engineers are able to share their expertise and experiences to the nation's next generation of technical leaders.

The Kennedy Space Center's house FIRST team, known as the Pink Team, consists of high school students from Rockledge, Cocoa Beach, and Viera, Florida. In this photo, the Pink Team shows off its robot to Kennedy's Deputy Director Janet Petro and Engineering Director Pat Simpkins at the Florida FIRST Robotics Competition in early March. (Credit: NASA/G. Benson)

During the live broadcast in January, FIRST founder Dean Kamen and designers of the annual challenge revealed the competition scenario for 2011. The estimated 30,000 student and engineering mentors, comprising the nearly 2,000 teams, then had a frenzied six weeks to design and build their robots. Each year, FIRST presents a new robotics competition scenario with twists and nuances to challenge both rookie and veteran teams. Each team receives a kit of parts and has six weeks to design and build a robot based on the team's interpretation of the game scenario. Other than dimension and weight restrictions, the look and function of the robots is up to each individual team.

### *NASA's Spaced-Out Sports challenge*

In May 2011, NASA announced three winners in the Spaced Out Sports competition, which challenged U.S. students in fifth through eighth grades to create games for astronauts to play aboard the International Space Station. The challenge is part of a broader Agency education effort to engage students in STEM activities.

The Spaced Out Sports challenge, a Teaching from Space project, is focused on helping students learn and apply Sir Isaac Newton's Laws of Motion. Using the accompanying curriculum, teachers led students through a study of Newton's laws, highlighted by hands-on activities and video podcasts featuring NASA scientists and engineers explaining how the laws are used in the space program.

The videos also feature celebrity athletes explaining the science behind their sports. Contributors include Olympic gymnast Nastia Liukin, NASCAR driver Juan Pablo Montoya, Women's National Basketball Association player Temeka Johnson, National Hockey League player Ryan O'Reilly, and members of the National Football League's New Orleans Saints.

Students learned the differences in a game played in the gravity environment of Earth and the same game played in a microgravity environment, such as the International Space Station. They used the knowledge to design or redesign a game to illustrate and apply Newton's laws.

Find out more about this year's winners and the games they created.

### *NASA selects classroom teachers for SOFIA science flights*

In May, NASA selected six teachers to work with scientists aboard the Stratospheric Observatory for Infrared Astronomy (SOFIA) during research flights in May and June. This was the first team of educators selected to participate in SOFIA's Airborne Astronomy Ambassadors Program. The six teachers selected for the SOFIA program submitted applications that included plans for taking their training and flight experience back to their classrooms.

SOFIA is a highly modified Boeing 747SP aircraft fitted with a 100 inch-diameter telescope. It analyzes infrared light to study the formation of stars and planets, chemistry of interstellar gases, composition of comets, asteroids and planets, and supermassive black holes at the center of galaxies. As a member of an Educator Ambassador team, teachers will fly on a SOFIA science flight and will receive training associated with the flight and the scientific research. They also will have access to scientists and educational information through electronic communications, receive an active astronomy kit, and support materials for education and outreach like brochures, bookmarks, and stickers.

## Outcome 6.1

Improve retention of students in STEM disciplines by providing opportunities and activities along the full length of the education pipeline.

| FY 2011 Performance Goal | | | | | FY 2011 |
|---|---|---|---|---|---|
| Provide educators nationwide with knowledge and tools with which to inspire students in STEM fields. | | | | | 6.1.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| 75,000 educators participate in NASA education programs. | 7ED6 Green | 8ED05 Green | 9ED7 Green | 10ED07 Green | ED-11-3 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide higher education students with authentic NASA mission-based opportunities that build knowledge and skills needed for STEM careers. | | | | | 6.1.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| 25,000 undergraduate and graduate students participate in NASA education opportunities. | None | None | 9ED6 Green | 10ED05 Green | ED-11-4 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Provide elementary and secondary students with authentic NASA mission-based opportunities that build STEM knowledge, skills and career awareness. | | | | | 6.1.2.2 Green |
| **FY 2011 Annual Performance Goals** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| 600,000 elementary and secondary students participate in NASA instructional and enrichment activities. | 7ED6 Green | 8ED04 Green | 9ED8 Green | 10ED08 Green | ED-11-5 Green |
| 75 percent of elementary and secondary students express interest in STEM careers following their involvement in NASA education programs. | 7ED4 Green | None | 9ED10 Green | 10ED06 Green | ED-11-6 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Promote equal opportunity compliance and encourage promising practices among NASA grant recipient institutions through a fully-realized program of civil rights compliance reviews, policy guidance, and technical assistance. | | | | | 6.1.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Equal opportunity (EO) assessment and technical assistance provided, or onsite compliance assessment performed, on-location at five STEM or STEM-related programs that receive NASA funding. | None | None | None | 10WF11 Green | AMO-11-19 Green |

# Outcome 6.2
## Promote STEM literacy through strategic partnerships with formal and informal organizations.

The complexity of meeting formal and informal education needs and requirements demands a highly collaborative approach. Through strategic partnerships, NASA Education leverages the resources and expertise of its partners, scales its investments to reach new audiences, and expands established networks. Tapping into partners' creativity and innovation helps disseminate NASA's products and services in a broader and more systematic manner to reach new users more effectively. By helping educators incorporate NASA content into school curricula or after-school programming, NASA cultivates strategic partnerships with both formal and informal education providers to promote science, technology, engineering, and mathematics (STEM) literacy.

NASA provides numerous opportunities for K–12 educators to engage directly with the science and engineering work conducted by the NASA mission directorates—helping educators meet the needs of their students in a resource-scarce environment. The high quality, inquiry-based curriculum materials for STEM learning developed by NASA mission directorates are used by teachers for formal education activities in their classrooms, and by NASA partner organizations who conduct educational activities with students in informal settings. NASA Education works with local, state, and Federal organizations to ensure that NASA's services and products provide information and opportunities that are appropriate, meet established needs, and support ongoing STEM initiatives.

Partnerships for formal education, particularly with higher education institutions and aerospace companies, focus on engineering and research efforts under the supervision of practicing professionals. These partners are able to provide independent research projects for undergraduate and graduate students and expand greatly what NASA can host at its facilities alone.

NASA's educator professional development projects provide educators with in-depth training and teaching materials on NASA mission topics that can enhance their regular classroom instruction. Subject matter experts often help Education develop the training and teaching materials and provide support through in-person presentations, online chats, or other types of interactions. Both formal and informal education partners use NASA's curricular support resources (e.g., videos, vodcasts, interactions with NASA scientists and engineers), which showcase NASA's mission activities, strengthen learners' understanding of engineering and technology innovations at NASA, and illustrate the connection between academic subjects and skills with real world applications.

Below are examples of fiscal year activities for this outcome:

### *NASA teams with the NRC to create science standards*

In 2011, the National Research Council (NRC) of the National Academies released *A Framework for K–12 Science Education*, which specifies eight science and engineering practices that students should learn and use over the course of their schooling, such as asking questions and defining problems, analyzing and interpreting data, and engaging in argument from evidence. It is designed to bring greater coherence to the science education that students receive across grades K–12. The framework also calls for a full integration of the practices of science with the ideas and concepts. That is, students should learn the ideas of science through actually doing science. NASA Education will work with the non-profit organization identified by the NRC to create science standards that identify the key scientific practices, concepts and ideas that all students should learn by the time they complete high school, based on the framework. The new standards should be completed in late 2012.

### *Summer of Innovation leverages strategic partnerships to share NASA's STEM content*

President Obama's "Educate to Innovate" campaign challenged the nation to foster a renewed commitment to strengthen America's literacy in science, technology, engineering, and mathematics (STEM). In response to the President's call to action, NASA launched the Summer of Innovation (SoI) project. SoI strategically partners with summer and other out-of-school time programs to build the capacity of school- and community-based organizations, tailors NASA support to address local needs, and facilitates the infusion of NASA content into summer and out-of-school time learning. SoI is specifically targeted at underserved and underrepresented students in grades 4–9. In 2011, NASA and SoI made

eight National Awards, partnered with more than 130 organizations and school districts through its Center awards, and distributed almost 200 Mini-Grant awards. The SoI project had a presence in 46 states, the District of Columbia, and Puerto Rico.

The SoI project design aligns with the 2010 report from the President's Council of Advisors on Science and Technology, which encourages partnerships between Federal education programs and non-profits while targeting underrepresented students. Because strategic partnerships significantly contribute to the execution and success of the SoI's implementation, the 2011 solicitation required organizations to include partnerships with a local school or school district for the purposes of increasing the potential for scalability.

In 2011, SoI made eight awards of up to $750,000 over four years to National Awardees—large, proven providers of STEM content to SoI's targeted audiences. The selected organizations pledged to partner with school districts to provide 2,500 middle school students with forty hours of Summer of Innovation STEM activities or content during the summer and to provide 25 hours of content during the school year. To increase the STEM teaching capacity of the selected organizations and to further encourage collaboration between the formal and informal education communities, these SoI National Awards also required the participation of 150 certified teachers in delivering content to students. In addition, SoI provided forty hours of professional development to participating teachers.

NASA's Centers have extensive experience engaging local community partners in summer programming for students across the country. SoI 2011 Center Awards enhanced NASA's ability to support STEM programming through the Centers' collaborations with individual organizations or consortiums that benefited from the use of Center resources, facilities, and personnel. NASA awarded an average of $150,000 in SoI funding to each of the nine NASA Centers and the Jet Propulsion Laboratory. In turn, each Center leveraged partnerships with schools and/or summer learning organizations to provide 20 hours of SoI STEM content to 1,500 middle school students.

SoI partnerships were also formed with small and non-traditional NASA audiences. During the pilot of the SoI project in 2010, numerous organizations expressed interest in partnering with NASA in Summer Learning. Many of the organizations that provide opportunities to the SoI target audience are community based, and do not have substantial experience in government partnerships. NASA used the mini-grant opportunity to focus on these smaller organizations across the country to introduce them to Summer of Innovation content and themes. In partnership with the National Space Grant Foundation, SoI awarded mini-grants of up to $2,500 to sites to provide at least six hours of NASA STEM content to students or professional development to teachers during summer and out-of-school time.

Students participate in a SoI activity conducted by Tomorrow's Aeronautical Museum in Compton, California. NASA partnered with over 130 organizations for SoI in 2011 through National Awards, Center Awards, and Mini-Grants. (Credit: TAM)

### *NASA and the LEGO Group partner to inspire children to build and explore the future*

A LEGO Space Shuttle that headed to orbit marked the November 2010 signing of a Space Act Agreement between NASA and the LEGO Group to spark children's interest in STEM. The partnership marks the beginning of a three-year agreement that will use the inspiration of NASA's space exploration missions and the appeal of the popular LEGO bricks to spur children's interest in STEM. The theme of the partnership is "Building and Exploring Our Future."

To commemorate this new relationship, the small LEGO Shuttle launched with the crew of the Space Shuttle Discovery on its final mission, which launched February 24, 2011, from NASA's Kennedy Space Center in Florida. As part of the Space Act Agreement, NASA also sent special LEGO sets to the International Space Station aboard Shuttle *Endeavour*'s STS-134 mission in May 2011.

As part of NASA and the LEGO Group's partnership kickoff, the Kennedy Space Center set up a 40-by-70-foot activity tent on November 2, 2010, at the Shuttle launch viewing site on the NASA Causeway. The partners invited children of all ages to get creative and build their vision of the future with LEGO bricks. (Read more about this story.)

NASA's partnership with LEGO Group couples the excitement of NASA's missions with kids' love of builiding with the iconic LEGO bricks. Projects with LEGO not only foster creativity and inspire the next generation of explorers, but also instill in the young builders a real sense of the engineering and design principles that NASA uses every day.

The LEGO Group has released four NASA-inspired products in their LEGO CITY line throughout 2011. In addition to the Space Shuttle, they have released a Space Moon Buggy, a Space Center, and a Satellite Launch Pad. The space-themed products vary in terms of complexity, engaging audiences from young children to adult LEGO fans. Each product contains NASA-inspired education materials. (Visit the LEGO space product site at http://www.legospace.com/.)

Students build launch vehicles from a pile of LEGO bricks at the "Build the Future" event held on November 3, 2010. (Credit: NASA/B. Ingalls)

### *The Endeavor Science Teaching Certificate Project opens doors*

Educators participating in the NASA Endeavor Science Teaching Certificate Project (ESTCP) receive professional development that opens doors of opportunity for their students, as well as the educators themselves. In 2011, Endeavor Fellows had a new opportunity to use their coursework toward earning national board certification.

The Endeavor online professional development model is designed to create a national cadre of over 200 Endeavor Fellows who demonstrate leadership in the use of NASA-related STEM content within their classrooms and in educator workshops at the district, regional, and state levels. Since 2009, the NASA ESTCP has funded up to 50 educators a year to participate in online graduate courses in a live format. Throughout their individualized professional development, Endeavor Fellows explore how they will incorporate the content and best practices in their respective classes. The required Action Research Plan and Methods in STEM Education courses require participants to apply and evaluate delivery of the content and instructional methods. U.S. Satellite Laboratory, Inc., and its partners of various state departments of education administer the ESTCP.

ESTCP Fellow, Julie Gabrovic, had taught physical education for 18 years in Florida when her principal asked her if she would teach a science lab part time. To prepare for teaching science, Gabrovic subscribed to the NASA EXPRESS listserv. This listserv sends subscribers a weekly e-mail with information about NASA opportunities and teaching materials. It was through EXPRESS that Gabrovic learned of ESTCP.

In addition to the required courses, Gabrovic selected three elective courses. It was her elective course "Lessons From the Ocean" that helped open doors of opportunity for Gabrovic and her students when they participated in a Webcast—The Oilspill One Year Later—with professors from Columbia Teachers College and other NASA fellows.

Additionally, during summer 2011, Gabrovic completed an internship at NASA's Goddard Space Flight Center in Greenbelt, Maryland. The internship was the result of a proposal that she submitted for an opportunity that was only available to Endeavor Fellows. The opportunity, Formal and Informal Planetarium Earth Data Partnership, calls for the Fellow and a planetarium educator to create an interactive exhibit for their local planetarium. Gabrovic's exhibit will be based on the topic "How is the ocean an integral part of the water cycle?"


Since participating in the ESTCP, Julie Gabrovic (right) has become the chair of the science department at her school and is part of the science and mathematics task force in her school district. (Credit: J.Gabrovic)

## Outcome 6.2

Promote STEM literacy through strategic partnerships with formal and informal organizations.

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Provide educator professional development experiences and materials that align to needs and opportunities identified by districts, states, Department of Education, professional organizations, and other stakeholders. | 6.2.1.1 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| 5,000 educators use NASA resources in their curricula after participating in NASA professional development. | 7ED6 Green | 8ED05 Green | 9ED7 Green | 10ED07 Green | ED-11-7 Yellow |
| | None | None | 9ED9 Green | 10ED09 Green | |

***Why NASA rated APG ED-11-7 Yellow:*** The ability to collect data from educators who have participated in NASA professional development is highly dependent upon those educators' response rates to follow-up surveys. Currently, NASA sends follow-up surveys to educators who have participated in an Agency-sponsored professional development program via e-mail, 120 days after the educator's experience. Tens of thousands of educators participate in NASA's programs, but only a small percent complete and submit the follow-up surveys. In FY 2011, less than 5,000 educators replied to the survey. NASA is generally able to establish and maintain ongoing relationships with higher education faculty because it is not difficult to obtain the necessary data on their use of NASA resources in their curricula. However, this proves to be extremely difficult with most K–12 and informal educators. Based on this, NASA continues to improve data collection methods. (See page 157 for the Performance Improvement Plan.)

| FY 2011 Performance Goal | FY 2011 |
|---|---|
| Provide expertise in the development of STEM education policies and strategies. | 6.2.1.2 Green |

| FY 2011 Annual Performance Goal | FY07 | FY08 | FY09 | FY10 | FY 2011 |
|---|---|---|---|---|---|
| Provide expertise to support the National Academies development of a framework for integrated science and engineering standards. | None | None | None | None | ED-11-8 Green |

# Outcome 6.3

## Engage the public in NASA's missions by providing new pathways for participation.

NASA encourages active participation in the Agency's programs and Mission, consistent with the philosophy of government transparency. Participatory engagement seeks to include the public in the adventure and excitement of NASA's activities and tap into individual creativity and capabilities to enhance its work in science, discovery, and exploration.

NASA's participatory engagement activities, led by the Office of Communications, span the communications spectrum ranging from passive activities—like watching online NASA videos—to highly interactive activities that use NASA-related social media tools or provide hands-on experiences. NASA also uses these activities to collaborate with the public on interpretation of data and discoveries. By increasing the mechanisms through which the public can directly and specifically contribute to NASA's missions, the Office of Communications can bring additional creativity and capability to some of the biggest challenges, and leverage NASA's resources to accomplish more toward the Agency's goals.

Below is a summary of fiscal year activities for this outcome:

### *Using new technologies to reach the public*

Some people may choose to participate simply by watching NASA Television or by visiting a NASA exhibit. Others choose to communicate with NASA via Twitter or Facebook, and actively participate in NASA events such as Tweetups. Still others form teams to enter NASA challenges. By 2015, NASA's goal is to establish a portfolio of participatory engagement opportunities throughout the Agency.

In FY 2011, the NASA Office of Communications began creating a process to identify and promote participatory engagement activities across the Agency, the first step toward establishing a baseline of activities. Each NASA program and mission would be encouraged to build some participatory engagement opportunities into their program design, and the Office of Communications will help each program and mission promote those opportunities to the appropriate audience.

The Office of Communications will compile its findings about participatory engagement into a report to the Office of Management and Budget as part of a review process for future submission to Congress, per Section 408 of the NASA Authorization Act of 2008.

### *NASA's iPad app beams science straight to users*

NASA satellites beam data from space; now the Agency is beaming it straight to iPads, placing NASA Earth science in the public's hands.

In July 2011, software and media specialists at the NASA Goddard Space Flight Center released a new iPad app—the NASA Visualization Explorer—that allows users to easily interact with extraordinary images, video, and information about NASA's latest Earth science research. The app's science features include high-resolution movies and stills and short written stories to put all the pieces in context. Most of the movies are simply real satellite data, visualized. Other features include interviews with scientists and imagery from supercomputer modeling efforts.

NASA's iPad app makes science from NASA's research efforts widely accessible in an engaging, easy-to-consume, thoroughly modern style. The visualization capabilities of the app add meaning to the often intangible, but essential data delivered from NASA research.


The NASA Visualization Explorer (shown here) joins NASA's other free iPad apps, all released in 2011: AstroApp: Space Shuttle Crew, NASA Television, AstroApp: Space Station Crew, and NASA Desert RATS Virtual Test Site. (Credit: NASA)

Work began on the NASA Visualization Explorer shortly after Apple released its electronic tablet in April 2010. The design team for the application's user interface knew immediately that the iPad provided the perfect platform to showcase NASA science.

The app, which is free from the iTunes App Store, includes social networking interfaces, like links to Facebook and Twitter for easy sharing of stories.

### *TEDxNASA comes to the west coast*

On August 17, 2011, TEDxNASA@SiliconValley became the Agency's first such event held on the west coast. Held in San Francisco, this independently organized event was in the spirit of the TED (technology, entertainment, and design) conferences that bring together leading thinkers to create a dialogue about important global challenges.

Attendees and visitors at TEDxNASA@SiliconValley gathered to discuss the theme "Extreme Green." Those who could not attend on site could participate online with chat and streaming video. The goal of TED events is to bring together people with diverse backgrounds and points of view, and the August event lived up to this goal by hosting a genome scientist, an environmental visionary, an astronaut/engineer, a test pilot, a filmmaker, a singer/songwriter, and many others.

Visitors at TEDxNASA@SiliconValley pass by rows of monitors, including one showing images taken by the Solar Dynamics Orbiter (SDO). (Credit: TEDxNASA)

Representatives from Center Media and Public Relations Offices, which serve the Office of Communications, coordinate the events with partners from professional organizations and industry. Visit the TEDxNASA site for information about upcoming and past events.

| **Outcome 6.3** | | | | | |
|---|---|---|---|---|---|
| Engage the public in NASA's missions by providing new pathways for participation. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| By 2015, establish an Agency-wide portfolio of participatory engagement opportunities. | | | | | **6.3.1.1 Green** |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Identify candidate mechanisms to encourage public engagement in NASA programs and missions. | **None** | **None** | **None** | **None** | **AMO-11-20 Green** |

# Outcome 6.4

## Inform, engage and inspire the public by sharing NASA's missions, challenges, and results.

The opportunities and means for sharing information have increased tremendously with the Internet, social media, and other new technologies. For scientific and programmatic announcements, NASA continues traditional communications activities like issuing press releases, hosting media events, and providing photographs and videos of missions and events. Additionally, the Office of Education, the Office of Communications, and the mission directorates are expanding their content to reach more diverse audiences. For example, interactive experiences with astronauts, scientists, and engineers, through an online presence and other outreach events, are well-suited for engaging the public and students. As discussed in Outcome 6.3, the Office of Communications is taking advantage of recent and emerging technologies and media (Tweetups, live streaming video, social media) to deliver NASA information to a more diverse audience.

NASA's education strategy includes a targeted effort to refresh current linkages and develop new ties with the education community, Federal agencies, corporations, and nonprofit organizations to infuse NASA's science, technology, engineering, and mathematics (STEM) content into classrooms and beyond. NASA promotes STEM literacy and awareness of its mission through strategic partnerships and linkages between formal and informal education providers. The Office of Education partners with industry stakeholders, academic institutions, museums, science centers, planetariums, Challenger Centers for Space Science Education, and other Federal agencies like the Department of Education.

NASA shares the direct results of its missions by releasing scientific data to researchers and other government agencies. The Agency contributes data to online portals like http://www.data gov, allowing its use by anyone with the capability to access it. NASA Web sites host a wealth of mission and program information, and NASA participates fully in Administration initiatives for transparency by providing specific program and project information through information-sharing portals.

Below are some of the activities that contributed to this outcome:

### *Space Shuttle launch provides unique event opportunity for students and NASA Education*

In conjunction with the final Space Shuttle flight, STS-135, the Office of Education used a cutting edge style of conference developed by tech companies to gather feedback from its constituents called an "unconference." An unconference has no set agenda or prescribed desired outcome. Instead, the participants (in this case students) rather than the organizers guide the discussions, encourage creative interaction, and debate among the attendees. NASA invited 200 affiliated high school, undergraduate and graduate students to attend the STS-135 unconference, held the day before the launch of STS-135, July 8, 2011, at the Marriott World Center in Orlando, Florida. Students came from 20 states, the farthest being Alaska.

The unconference was a listening exercise for NASA, allowing Education and other NASA leaders to learn about students' interests and vision for the future of NASA and the U.S. space program. There were four specific interest areas the students discussed: aeronautics, space exploration, robotics, and technology. NASA invited subject matter experts both from NASA and organizations specializing in each area to work with NASA Education facilitators and NASA Student Ambassadors to answer students' questions and to facilitate a free form conversation. Throughout the day, sessions became quite spirited with students debating the finer points of the various subject areas.


(Left) A college student listens intently during the Subject Matter Experts' Reflections panel at the STS-135 Unconference. (Right) NASA Associate Administrator for Education, Leland Melvin, provided closing remarks at the STS-135 Unconference. As a NASA Astronaut who has flown on two space shuttle missions, Melvin serves as an inspirational leader and role model to encourage students in their pursuit of STEM-related studies. (Credit, both photos: Corporate Visual Services/ T. Cuffel)

Hundreds of thousands of visitors—students, educators, and families—explore NASA science and technology every year at the NASA visitor centers. Located near or on the site of each of NASA's 10 Centers, each visitor center conveys the NASA story through each Center's unique contributions. In the Jet Propulsion Laboratory's visitor center, full-scale spacecraft models take visitors on a tour of Earth, the solar system, and the universe through each robotic explorer's experiences: Galileo to Jupiter; Voyager 1 and 2 to Jupiter, Saturn, Uranus, Neptune, and beyond; and Mars Pathfinder and the Mars Exploration Rovers across the Red Planet's surface. Visitors can get up close and personal with meteorites from asteroid Vesta (currently being explored by NASA's Dawn spacecraft), and an interactive model of a Deep Space Network tracking antenna. Tour guides use a giant multi-touch screen to demonstrate scale in the solar system, the electromagnetic spectrum, and facilities at the Jet Propulsion Laboratory. Visitors also can watch over 70 engaging videos at stations around the room and explore scale models of the planets and other spacecraft. (Credit: NASA/JPL-Caltech)

Once the breakout sessions were complete, the invited subject matter experts lead a reflection panel and provided to the students feedback on the day's discussions. This led to a discussion about how NASA could further students' interest in STEM studies.

The following day, all 200 students and approximately 400 VIP Office of Education guests attended the final launch of the Space Shuttle, STS-135.

### *Delivering information to the public—faster and better*

By using social media tools and direct interaction with stakeholders, NASA is able to listen to the American taxpayer, as well as inform them about NASA missions and challenges. Through traditional and emerging tools, NASA broadly shares timely, accurate and consistent information, and promotes and open, transparent government. NASA is working to coordinate its activities across the Agency through a framework, governance model, implementation plan and portfolio for all NASA communications activities. Furthermore, NASA is complying with federal laws and regulations for the Freedom of Information Act (FOIA), under which the public can request records from Federal agencies. In FY 2011, NASA reduced the backlog of FOIA responses by 25 percent. The improvement is due to collaboration, streamlining the program and processing in accordance with the law. The elimination of the backlog allows NASA's FOIA Office to address and process all requests immediately within the constraints of the law.

### *NASA joins USA Science & Engineering Festival in Washington*

NASA joined more than 500 science organizations in late October 2010 to inspire the next generation of scientists and engineers during the first national science and engineering festival to be held in the Nation's capital.

The USA Science & Engineering Festival began with activities in local schools and ended with a two-day expo on the National Mall and surrounding areas. The event also marked the culmination of NASA's new Summer of Innovation pilot education initiative, aimed at engaging middle school students in STEM activities during the summer break. The program reached more than 75,000 middle school students during its inaugural year.

The festival was a dynamic way to reach and excite students and the general public about NASA many scientific missions. Booths at the

During a 2011 Summer of Innovation camp, hosted by Langley Research Center and the Thomas Nelson Community College's Williamsburg campus, a young rocketeer builds her rocket. NASA Langley's informal education team worked with children from Big Brothers/Big Sisters organization to build and launch the rockets. (Credit: NASA/S. Smith)

expo featured hands-on activities, demonstrations, and exhibits that brought exploration and discovery to life. Students also learned how to become involved in 2011 Summer of Innovation events. The Summer of Innovation pilot program, which began in June, used the same successful approach to engage middle school students across the Nation in STEM activities.

### *Bringing NASA to the public*

In FY 2011, 421 museums and science centers across the country actively engaged the public in major NASA events. Much of this engagement was facilitated through NASA's Museum Alliance, a free-of-charge NASA STEM content facilitation service and online education community. The Museum Alliance offers educators real-time NASA information for use with all visitors to informal education institutions.

### *Astronomy Day at the State Museum of Nebraska*

Visitors to the State Museum of Nebraska on May 7, 2011, found some very modern items among the museum's existing dinosaur exhibit—several NASA telescopes. The museum's Astronomy Day featured a unique opportunity for over 500 visitors to see the telescopes and receive demonstrations of how they work.

The NASA Museum Alliance, which made the museum's Astronomy Day possible, gives visitors access to current NASA science and technology by loaning NASA materials to museums. The Museum Alliance also provides the museum's staff professional development and access to NASA scientists and engineers. Over 800 professionals at more than 420 U.S. museums, science centers, planetariums, NASA Visitor Centers, Challenger Centers, observatories, parks, nature centers, zoos, and aquariums are partners in the Museum Alliance. Museum Alliance partners present a variety of space exploration and aeronautics programs and events—exhibits, planetarium shows, educator workshops, and special lectures—for their local communities.

A guide at the State Museum of Nebraska shows a NASA telescope to visitors. (Credit: J. Dunn, University of Nebraska, Lincoln, Ralph Mueller Planetarium)

| Outcome 6.4 | | | | | |
|---|---|---|---|---|---|
| Inform, engage, and inspire the public by sharing NASA's missions, challenges, and results. | | | | | |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Leverage communities of practice to facilitate sharing of NASA successes and challenges with the public. | | | | | 6.4.1.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| 420 museums and science centers across the country actively engage the public in major NASA events. | None | 8ED06 Green | 9ED11 Green | 10ED10 Green | ED-11-9 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Use current and emerging communications technologies to reach increasingly broad audiences. | | | | | 6.4.2.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Establish an Agency-wide portfolio of communication tools. | None | None | None | None | AMO-11-21 Green |
| **FY 2011 Performance Goal** | | | | | **FY 2011** |
| Make available Agency records through the Freedom of Information (FOIA), Privacy Act, and Open Government Initiative in accordance with federal laws and regulations. | | | | | 6.4.3.1 Green |
| **FY 2011 Annual Performance Goal** | **FY07** | **FY08** | **FY09** | **FY10** | **FY 2011** |
| Issue Agency-wide Freedom of Information Act (FOIA) tools to support consistent responses to requesters. | None | None | None | None | AMO-11-22 Green |

Introduction

# Performance Improvement Plans

## Performance Improvement Plans by Category

This section provides the explanations and performance improvement plans for any unmet performance measures in FY 2011 and, where applicable, their link to the previous year's performance.

When a NASA program does not meet its commitment as stated in the annual performance plan, responsible program officials must explain the performance shortfall and provide an improvement plan for correcting the issue. This year, in an effort to provide better performance improvement plans, NASA assessed the explanations and looked for trends in root causes, to inform senior management on any cross-cutting corrective actions that may be warranted. In addition, NASA used the information on management and performance challenges, as identified by the NASA's Office of Inspector General (OIG) and the Government Accountability Office (GAO), to help guide setting these improvement plans.

In FY 2011, NASA's OIG identified five areas that pose the top management and performance challenges to NASA leadership: the future of U.S. space flight, project management, infrastructure and facilities management, acquisition and contracting management, and information technology security and governance. GAO previously identified high risk factors along the same vein, including managing information technology, antiquated financial management systems, poor cost estimating, underestimated risks associated with development of major systems, and inadequate acquisition management in view of persistent cost growth and schedule slippage in the majority of projects. More information on OIG and GAO assessments of NASA can be found in the Management Challenges letter from NASA's OIG located in this report (see page 247) and on the GAO High Risk Web site.

With the themes presented by OIG and GAO in mind, NASA categorized the measures and information on their shortfalls to provide context to the reader for why groups of measures may have been unmet. NASA has placed its performance shortfalls, and ensuing improvement plans into the following categories:

Looking forward, NASA will build upon the progress already made within some of these categories, such as corrective actions to mitigate cost growth and schedule slippage. Specifically, over the last five years, NASA fundamentally transformed how it manages its programs and projects, acquisition strategies, and procurements, including strengthening program and project management, establishing more rigorous cost estimation practices, and revising procurement practices and systems.

In subsequent years, NASA will track progress toward these plans and analyze the performance improvement trends in an effort to strengthen Agency performance.

# Measures Requiring Improved Measurement Methods

NASA has an integrated system to plan strategy and implementation; monitor, assess, and evaluate performance toward commitments; identify issues; gauge programmatic and organizational health; and provide appropriate data and information to NASA decision-makers. NASA's planning and performance management processes provide data to Agency management through ongoing monthly and quarterly analyses and reviews; annual assessments in support of budget formulation (for budget guidance and issue identification, analysis, and disposition); annual reporting of performance, notification of management issues, and financial position; periodic, in-depth program or special purpose assessments; and recurring or special assessment reports to internal and external organizations. To ensure that these performance assessments provide the necessary information, NASA periodically revisits the effectiveness of its measures. Sometimes NASA identifies issues with the design of a measure, the method of data collection, or the practicality of a performance target, as well as some inaccuracies in metrics. This fiscal year, data collection methods for two measures did not yield enough information to accurately measure performance. NASA plans to improve on these data collection methods.

| | | |
|---|---|---|
| **Fiscal Year 2011 Performance Improvement** | **ST-11-15 (Performance Goal 3.4.1.3)** | |
| | **Accountable Organization: Innovative Partnerships Program** | |
| | Greater than 35 percent of the Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) Phase II technology projects awarded between 2004-2008 will be transferred into commercial products or services. | **FY 2011 Red** |
| | ***Why Measure ST-11-15 was Not Met:*** Based on NASA's current measurement method, NASA determined that it awarded 23.7% of SBIR/STTR projects (182 of 766) between 2004 and 2008 and had extended them past Phase II. NASA believes the numbers of commercialization successes are greater than the current methods indicate. To achieve commercialization, these projects used either NASA Phase III funds or an alternative source of non-NASA funding to develop the technology. Commercialization is a metric broadly defined by the SBA as a measure of the ability of SBIR/STTR contractors to successfully receive non-SBIR/STTR revenues for broad market, as well as other government applications, for technologies they developed under the SBIR/STTR programs. At NASA, this is defined as the sum of technology "infused" into NASA programs (metric 3.1.1.4), procured by other government agencies, and/or used in the commercial marketplace. The collection of non-NASA applications for this metric requires the voluntary sharing of information by SBIR/STTR contractors with NASA personnel. NASA continues to consider alternative methods of data collection that will lead to increasing accuracy in the measurement of commercialization successes. | |
| | ***FY 2011 Performance Improvement Plan:*** To acquire a greater amount of verifiable data, the SBIR/STTR program has instituted a survey as part of its 2011 SBIR/STTR solicitation requiring firms submitting proposals to share information with NASA on their success at commercializing technologies developed under previous SBIR/STTR awards. Data from this survey will be collected and analyzed in FY 2012. NASA plans to continue to use surveys in future SBIR/STTR solicitations so that NASA can compile a database of past commercializations, and when combined with infusion data on NASA programs (metric 3.1.1.4), provide a more accurate accounting of the commercialization data requested in metric 3.4.1.3. | |
| **Fiscal Year 2011 Performance Improvement** | **ED-11-7 (Performance Goal 6.2.1.1)** | |
| | **Accountable Organization: Office of Education** | |
| | 5,000 educators use NASA resources in their curricula after participating in NASA professional development. | **FY 2011 Yellow** |
| | ***Why Measure ED-11-7 was Not Met:*** The ability to collect data from educators who have participated in NASA professional development is highly dependent upon those educators' response rates to follow-up surveys. Currently, NASA sends follow-up surveys to educators who have participated in an Agency-sponsored professional development program via e-mail, 120 days after the educator's experience. Tens of thousands of educators participate in NASA's programs, but only a small percent complete and submit the follow-up surveys. In FY 2011, less than 5,000 educators replied to the survey. NASA is generally able to establish and maintain ongoing relationships with higher education faculty because it is not difficult to obtain the necessary data on their use of NASA resources in their curricula. However, this proves to be extremely difficult with most K–12 and informal educators. Based on this, NASA continues to improve data collection methods. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA plans to explore more effective means for collecting follow-up data from educators who participate in Agency-sponsored professional development. This includes potentially decreasing the 120-day follow-up period, making the submission of survey responses a prerequisite for gaining continued access to certain curricular tools, or possibly direct follow-up by phone or focus group. NASA will also consider creative ways to possibly incentivize educators to submit completed surveys. NASA Education is currently collaborating with OMB to identify ways to strengthen the Agency's surveying techniques and overall data collection methods. | |

# Energy Use Management

Since the mid-to-late 1980s, NASA has worked to reduce energy usage in its institutional buildings and mission installations. NASA made significant progress in meeting previous requirements (National Energy Conservation Policy Act, Federal Energy Management Improvement Act of 1988, and Energy Policy Act of 1992) to reduce energy intensity from an FY 1985 baseline. NASA implemented many of the high-yield investments that led to significant decreases in energy intensity, before statutory and executive order changes ( Energy Policy Act of 2005 and Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management), adopted an FY 2003 baseline year for further energy intensity reduction. Additionally, Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance (2009), expanded upon the energy reduction and environmental performance requirements of E.O. 13423. The Agency will continue to improve our performance against targets for energy intensity, factoring all these requirements.

The performance measures below show the trend for energy intensity across a couple of years and NASA's plans for continuing to reduce it annually.

| | | |
|---|---|---|
| **Fiscal Year 2010 Performance Improvement** | **10FAC04** | |
| | **Accountable Organization: Office of Strategic Infrastructure** | |
| | Reduce energy intensity for facility energy use by 3% per year, from the FY 2003 baseline, for a total reduction of 30% (in Btu/gsf) by the end of FY 2015. | **FY 2010 Red** |
| | ***Why Measure 10FAC04 was Not Met:*** Energy intensity decreasing average of 1 percent annually and energy unit costs are increasing an average of 7.2 percent annually. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA is working to meet energy intensity reduction requirements of 3 percent per year and 30 percent by 2015, from the FY 2003 baseline. In an effort to assist Centers to administer their energy management programs, NASA Headquarters conducts Energy and Water Management Functional Reviews at a third of NASA Centers annually to help Centers improve their management systems and identifying and implementing energy conservation measures. In FY 2010, NASA invested $66 million for construction and revitalization projects at four NASA Centers that include major replacements of aging high energy use equipment with new energy efficient units, and initiated an Inter-Center Competition to reduce energy/water consumption. The competition encourages Centers to implement low-cost and no-cost initiatives to reduce energy and water usage. NASA will allocate $4 million of Strategic Institutional Investment funds for small energy and renewable projects in FY 2011 and an additional $22.3 million in FY 2012. This past fiscal year, NASA also initiated a Recapitalization Program that will replace aging facilities with new more energy efficient buildings. | |
| | ***Plan Update:*** NASA's progress is outlined below in the explanation and performance improvement plan for this same measure, which was reported on in FY 2011, as well. | |
| **Fiscal Year 2011 Performance Improvement** | **Performance Goal 5.2.3.2** | |
| | **Accountable Organization: Office of Strategic Infrastructure** | |
| | HPPG: Conserve valuable natural resources by reducing NASA's energy and water use. | **FY 2011 Yellow** |
| | ***Why Performance Goal 5.2.3.2 was Not Met:*** Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA expects to exceed its targets on the measures related to water use and fleet management, but fall short on the energy intensity goals. See rating explanation for ECR-11-1 for more detailed information on the energy intensity measure. | |
| | ***FY 2011 Performance Improvement Plan:*** Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA reduced energy intensity by an estimated 1%, for an 8% reduction from 2003 baseline. The FY 2011 goal was 18% from the 2003 baseline and NASA expects to reduce energy intensity by 10% (+/- 2%) in that same timeframe. Recent NASA topline budget reductions lowered funding planned for specific energy efficiency measures and new building construction, restoration and rehabilitation, which negatively impacted NASA's energy conservation program and reduced chances of meeting federal requirements. Despite the reduced funding, NASA continues to work to reduce energy intensity, and during FY 2010/FY 2011, the Agency completed construction and received LEED certification for 12 new buildings (1 Certified, 2 Silver, 6 Gold, and 3 Platinum). Three completed buildings are under review for certification (2 Silver and 1 Gold), and ten more buildings are under construction seeking LEED certification of Silver or Gold level in FY 2012. Eleven buildings are in the design phase for Silver or Gold LEED level. | |

| Fiscal Year 2011 Performance Improvement | ECR-11-1 (Performance Goal 5.2.3.2) | |
|---|---|---|
| | **Accountable Organization: Office of Strategic Infrastructure** | |
| | Reduce energy intensity use annually by three percent from an FY 2003 baseline. | **FY 2011 Red** |
| | ***Why Measure ECR-11-1 was Not Met:*** Final performance data for this goal will be available in January 2012. Based on third quarter estimates and trending data, NASA reduced energy intensity by an estimated 1%, for an 8% reduction from 2003 baseline. The FY 2011 goal was 18% from the 2003 baseline and NASA expects to reduce energy intensity by 10% (+/- 2%) in that same timeframe. Recent NASA topline budget reductions lowered funding planned for specific energy efficiency measures and new building construction, restoration, and rehabilitation, negatively impacting NASA's energy conservation program and reducing chances of meeting Federal requirements. Despite the reduced funding, NASA continues to work to reduce energy intensity, and during FY 2010–FY 2011, the Agency completed construction and received LEED certification for 12 new buildings (1 Certified, 2 Silver, 6 Gold, and 3 Platinum). Three completed buildings are under review for certification (2 Silver and 1 Gold), and ten more buildings are under construction seeking LEED certification of Silver or Gold level in FY 2012. Eleven buildings are in the design phase for Silver or Gold LEED level. | |
| | ***FY 2011 Performance Improvement Plan:*** To continue efforts to reduce energy consumption and improve NASA's aging infrastructure, the Agency designs and constructs new buildings to minimum LEED Silver standard. NASA is evaluating co-generation such as Combined Heat and Power (CHP) project at four Centers that have district type utility distribution systems. These large projects will reduce energy consumption, use waste heat to generate energy, and provide energy security. NASA is increasing energy savings performance contract (ESPC)/utility energy service contract (UESC) projects at Centers and has created a position at Headquarters to support Centers with implementation and execution of these complex projects. The Agency has two UESC projects under way and has three additional UESCs under consideration. NASA is also executing four ESPCs at Centers and is reviewing two additional project opportunities. Additionally, NASA has performed an Agency survey for renewable energy project opportunities and is evaluating the final report for project identification. The Agency has applied for in-kind EUL authority with the FY 2012 budget request to implement large renewable energy projects. | |

# Safety of Workforce and Assets

NASA continues to have Safety as a core value. As stated in the 2011 NASA Strategic Plan, "NASA's constant attention to safety is the cornerstone upon which we build mission success. We are committed, individually and as a team, to protecting the safety and health of the public, our team members, and those assets that the Nation entrusts to the Agency." For years, NASA has maintained high goals for safety and statistically exceeds much of the federal government on aspects such as lost time due to work-related injuries and illnesses. These standards are maintained despite the risky nature of spaceflight and the unique challenges it poses. The Agency has taken a "holistic" approach to addressing all the aspects of safety for the public, NASA employees, contractors and partners, and assets. Measures are tracked internally with senior management on a monthly basis, and key indicators are reported externally, including in the annual performance report. New policies, procedures, and corrective actions are implemented as specific issues or undesirable trends are seen in the data.

The table below demonstrates several key indicators where NASA did not meet its targeted goals and how performance toward these will be improved.

| | | |
|---|---|---|
| **Fiscal Year 2010 Performance Improvement** | **Outcome AS.4** | |
| | **Accountable Organization: Office of Safety and Mission Assurance** | |
| | While promoting mission success, protect the public, NASA workforce, high-value equipment and property from potential harm as a result of NASA activities and operations by factoring safety, quality, risk, reliability, and maintainability as integral features of programs, projects, technologies, operations, and facilities. | **FY 2010 Yellow** |
| | ***Why Outcome AS.4 was Not Met:*** There were 12 permanent partial disability (Type B) mishaps that occurred to contract employees during FY 2010. | |
| | ***FY 2010 Performance Improvement Plan:*** Policy and procedures are currently in place to provide guidance and education to the NASA workforce (civil service and contractor employees) to minimize mishaps. Management is provided an out brief after each Type A or B mishap with the goal of disseminating information that will reduce the potential for future occurrences. | |
| | ***Plan Update:*** In FY 2010, there were no NASA Type A or NASA Type B injuries for the NASA civil servant workforce and zero injuries or fatalities for the public. For FY 2010, there were 14 contractor Type B mishaps (after final Office of Workers Compensation Programs review and approval). For FY 2011, there were 10 type B contractor injuries reported, (an improvement (reduction) of 29%) from FY 2010. There was also a reduction by 50% in the amount of falls. There were no NASA Type A or NASA Type B injuries for the NASA civil servant workforce and zero injuries or fatalities for the public. But based on the number of Type B mishaps seen for contractors, and to assure continued performance against the goal, NASA Injury statistics were reviewed for trends and awareness campaigns were developed as needed. Based on the unfavorable trend of fall mishaps, a fall protection campaign was developed at the NASA Safety Center along with fall prevention campaigns at the Centers. | |
| **Fiscal Year 2010 Performance Improvement** | **10SMS02** | |
| | **Accountable Organization: Office of Safety and Mission Assurance** | |
| | Assure no fatalities or permanent disabling injuries to the NASA workforce resulting from NASA activities during the fiscal year. | **FY 2010 Red** |
| | ***Why Measure 10SMS02 was Not Met:*** There were no fatalities or permanent, total disabilities (Type A) to the NASA workforce during the fiscal year. However, there were 12 permanent partial disability (Type B) mishaps that occurred to contract employees. This was an increase compared to the previous year. There were no Type A or B injuries to NASA civil service employees. NPR 8621.1 defines a Type A mishaps as a permanent total disability and Type B as an occupational injury and/or illness that has resulted in a permanent partial disability. | |
| | ***FY 2010 Performance Improvement Plan:*** Policy and procedures are currently in place to provide guidance and education to the NASA workforce (civil service and contractor employees) to minimize mishaps. Management is provided an out brief after each Type A or B mishap with the goal of disseminating information that will reduce the potential for future occurrences. | |
| | ***Plan Update:*** In FY 2011, there were zero fatalities and permanent disabiling injuries to the public and NASA civil servant workforce. Based on a review of trends of FY 2011 mishaps and close calls, NASA will be implementing an awareness campaign on Electrical Safety, and what Occupational Safety and Health Administration calls Control of Hazardous Energy, which includes Lockout/Tag out. NASA adjusted this measure in FY 2011 to incorporate reporting against the President's POWER initiative. | |

| | | |
|---|---|---|
| Fiscal Year 2011 Performance Improvement | **AMO-11-10 (Performance Goal 5.2.1.2)** | |
| | **Accountable Organization: Office of Safety and Mission Assurance** | |
| | Reduce Total Case Rate and Lost Time Case Rate by one percent, in accordance with the President's Protecting Our Workers and Ensuring Reemployment (POWER) initiative. | **FY 2011 Red** |
| | ***Why Measure AMO-11-10 was Not Met:*** At year-end, NASA was about 2 times lower (better) than the President's Protecting our Workers & Ensuring Reemployment (POWER) goal for TCR and 5 times lower (better) than the POWER goal for LTCR. However, NASA undertook a stretch goal of lowering the Agency's already low rates by 1%, from the POWER baseline goal year (FY 2009). The data for this calculation is current through the third quarter (fourth quarter data is not available until December), with end-of-year projections by the Department of Labor's Office of Workers' Compensation Programs, who must validate and accept these cases, that place NASA at small upswings in both TCR and LTCR from the FY 2009 base year (thus missing the 1% internal goal). Even with the slight upswings, NASA still remains one of the best in the government, and still significantly below (better than) the POWER goals. | |
| | ***FY 2011 Performance Improvement Plan:*** Since NASA's rate already exceeded (better than) the Presidents POWER initiative and is one of the lowest in the government, NASA did not take any global initiatives to reduce this already excellent rate. However, spot initiatives were developed field center by field center to address specific trends in lost time and close call incidents. | |
| Fiscal Year 2011 Performance Improvement | **Performance Goal 5.2.1.3** | |
| | **Accountable Organization: Office of Safety and Mission Assurance** | |
| | By 2015, reduce damage to NASA assets by eight percent from the 2010 baseline. | **FY 2011 Red** |
| | ***Why Performance Goal 5.2.1.3 was Not Met:*** NASA does not anticipate meeting this performance goal by 2015, due to the Glory launch vehicle mishap, in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, irrespective of no damage beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals, that also feed this performance goal. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective action will be taken as needed. | |
| Fiscal Year 2011 Performance Improvement | **AMO-11-11 (Performance Goal 5.2.1.3)** | |
| | **Accountable Organization: Office of Safety and Mission Assurance** | |
| | Reduce damage to NASA assets by two percent per fiscal year, based on a five-year running average. | **FY 2011 Red** |
| | ***Why Measure AMO-11-11 was Not Met:*** NASA does not anticipate meeting this performance goal by 2015 due to the Glory launch vehicle mishap in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, even if there is no damage to any other NASA assets beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals that also feed this performance goal. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective action will be taken as needed. | |

**Additional Context**

**Performance Goal 5.2.1.2:** *By 2015, achieve a four percent reduction in the total case rate and lost time rate for the NASA civil service work force* is rated Green. NASA expects to remain on track for this performance goal under the current extrapolated projection, based on past trends.

# Taurus XL Launch Vehicle Failure

The Glory Earth-observing satellite was intended to improve our understanding of how the Sun and tiny atmospheric particles called aerosols affect Earth's climate. On March 4, 2011, Glory launched from Vandenberg Air Force Base in California. The countdown and launch went smoothly until the point at which the fairing should have separated from the vehicle. Telemetry indicated that the launch vehicle failed because the fairing, the protective shell atop the rocket, did not separate as expected about three minutes after launch, and as a result the launch vehicle did not deliver the Glory spacecraft to orbit. NASA has created a Mishap Investigation Board to evaluate the cause of the failure.

NASA's previous launch attempt of an Earth science spacecraft, the Orbiting Carbon Observatory onboard a Taurus XL on February 24, 2009, also failed to reach orbit when the fairing did not separate. NASA's Orbiting Carbon Observatory Mishap Investigation Board reviewed the launch data and the fairing separation system design and developed a corrective action plan. The plan was implemented by Taurus XL manufacturer Orbital Sciences Corporation. In October 2010, NASA's Flight Planning Board confirmed the successful closure of the corrective actions.

This second launch failure had far reaching impacts on NASA's reported performance. Multiple measures demonstrate the impact of the Glory launch mishap, which is reflective of how NASA works in an integrated manner, across multiple organizations, to ensure mission success. Since 1998, NASA has averaged a 97 percent mission success rate for all missions using expendable launch vehicles. The Office of Safety and Mission Assurance supports this success rate through the development, implementation, and oversight of Agency-wide safety, reliability, maintainability, and quality assurance policies and procedures. The Human Exploration and Operations Mission Directorate's Launch Services Program (LSP) works closely with other U.S. government agencies and the launch industry to ensure that the most safe, reliable, on-time, cost-effective commercial launch opportunities are available on a wide range of launch systems. The Science Mission Directorate develops and manages these missions and works with LSP to match their requirements with the appropriate reliable and available launch vehicle.

NASA will consider the results of the investigation when determining the next steps for providing reliable mid-sized launch services for NASA science missions. The lessons from addressing this mishap will respond to how all of these organizations continue to work together to ensure future mission success, which is reflected in the performance improvement plans outlined below.

| Mission Assurance and Launch Rate Success | | |
|---|---|---|
| **Fiscal Year 2011 Performance Improvement** | **Performance Goal 5.2.1.3** | |
| | **Accountable Organization: Office of Safety and Mission Assurance** | |
| | By 2015, reduce damage to NASA assets by eight percent from the 2010 baseline. | **FY 2011 Red** |
| | ***Why Performance Goal 5.2.1.3 was Not Met:*** NASA does not anticipate meeting this performance goal by 2015, due to the Glory launch vehicle mishap in fiscal year 2011. This goal is based on the average across five years of all realized costs of the damage to NASA's assets. Based on the magnitude of the cost of the loss of the Glory mission, the five year average will show a growth, rather than a reduction by 2015, even if there is no damage to any other NASA assets beyond FY 2011. However, with mission failure costs taken out and accounted for separately, NASA is projected to meet the institutional property and facility loss goals that also feed this performance goal. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective action will be taken as needed. | |

| | | |
|---|---|---|
| Fiscal Year 2011 Performance Improvement | **AMO-11-11 (Performance Goal 5.2.1.3)**<br>**Accountable Organization: Office of Safety and Mission Assurance** | |
| | Reduce damage to NASA assets by two percent per fiscal year, based on a five-year running average. | **FY 2011 Red** |
| | ***Why Measure AMO-11-11 was Not Met:*** This annual performance goal will not be met in FY 2011, due to the failure of the Taurus XL launch vehicle which resulted in the loss of the Glory mission. Based on the magnitude of the cost of the loss of the Glory mission, FY 2011 will see a growth from FY 2010, rather than a reduction. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective actions will be taken as needed. | |
| Fiscal Year 2011 Performance Improvement | **SFS-11-2 (Performance Goal 5.4.1.1)**<br>**Accountable Organization: Human Exploration and Operations Mission Directorate, Launch Services Program** | |
| | Sustain 100 percent success rate with the successful launch of NASA-managed expendable launches as identified on the Launch Services Flight Planning Board manifest. | **FY 2011 Yellow** |
| | ***Why Measure SFS-11-2 was Not Met:*** This annual performance goal was not met due to the loss of the Glory mission. NASA's Glory satellite did not reach orbit after its liftoff on March 4, 2011, due to a launch vehicle mishap. The Launch Services Program successfully launched the other three missions scheduled for this fiscal year. Aquarius successfully launched aboard a Delta II launch vehicle on June 10, 2011 from Vandenberg Air Force Base, CA. The Juno mission launched aboard an Atlas V rocket on August 5, 2011, from Cape Canaveral Air Force Station, FL. And lastly, the GRAIL mission launched aboard a Delta II Heavy launch vehicle on September 10, 2011. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA created the Glory Satellite Mishap Investigation Board to evaluate the cause of the failure. The board began its investigation in March 2011. Members will gather information, analyze the facts, identify the failure's cause or causes and identify contributing factors. The board will make recommendations to the NASA administrator to prevent similar incidents. The endorsed mishap report findings and recommendations will be reviewed by NASA senior management for both programmatic and for institutional failures, and corrective actions will be taken as needed. | |

### Additional Context

**Performance Goal 5.4.1.1:** *Complete Launch Services Program (LSP) objectives for all NASA-managed expendable launches* is rated Green. On average NASA, achieves its success rate for expendable launches, and expects to remain on track for future planned ones.

**Performance Measure ES-11-12:** *Complete the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) Mission Readiness Review* is rated Green. This annual performance goal was met. The NPP Mission Readiness Review was completed on September 6, 2011.

| Science Mission Objectives (Including Those Beyond Glory) | | |
|---|---|---|
| Fiscal Year 2011 Performance Improvement | **Performance Goal 2.1.5.2** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | HPPG: In support of studying Earth from space, NASA will make significant progress towards completion of the integration, test, launch, validation, and initiation of early on-orbit operations of the Glory and NPOESS Preparatory Project (NPP) missions prior to the end of fiscal year 2011. | **FY 2011 Red** |
| | ***Why Performance Goal 2.1.5.2 was Not Met:*** This high priority performance goal was not met, due to the loss of the Glory mission when the fairing from the Taurus XL launch vehicle failed to separate from the rocket. The National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission was successfully launched on October 28, 2011. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA continues to take actions to mitigate any impacts from the Glory launch mishap. The Science Mission Directorate (SMD) is evaluating the loss of the mission on the long-term science objectives and discussing the options available to keep on-track toward this performance goal. The relative priority for replacing the Glory measurements will be considered in the context of the Earth Science portfolio and all of its objectives. | |
| Fiscal Year 2011 Performance Improvement | **ES-11-13 (Performance Goal 2.1.5.2)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Complete the Glory Launch Readiness Review. | **FY 2011 Red** |
| | ***Why Measure ES-11-13 was Not Met:*** The Glory Launch Readiness Review was completed on February 21, 2011, with a second review completed on March 2, 2011. The spacecraft and instruments were checked out and prepared to successfully begin their mission. However, the Glory mission, which was launched from Vandenberg Air Force Base on March 4, 2011, did not reach orbit, due to a mishap with the launch vehicle. Initial evidence suggests that the fairing, which protects the spacecraft during takeoff atop the Taurus XL launch vehicle, did not separate as required, when it reached the appropriate altitude. | |
| | ***FY 2011 Performance Improvement Plan:*** See the FY 2011 Performance Improvement Plan for Performance Goal 2.1.5.2 above. | |

# Commercial Space Flight Development

Throughout FY 2010, NASA's Commercial Orbital Transportation Services (COTS) partners, SpaceX and Orbital, continued to make progress toward developing systems to provide cargo resupply services to the International Space Station. Commercial development is a new way of doing business for NASA, and the partners continue to learn and make progress. As the partners have transitioned from development to integration and testing, they have encountered technical challenges similar to the development of any major space system. Subsequently, the resolution of these challenges has caused delays to the partners' demonstration flights into FY 2011.

In December 2010, SpaceX launched its first demonstration of its COTS transportation capabilities. Both SpaceX and Orbital are expected to demonstrate proximity operations and berthing to the International Space Station (ISS) in FY 2012 to complete the COTS milestones and prove maturity of the systems for ISS commercial resupply services. In FY 2011, NASA augmented funding of the COTS Space Act Agreements to add additional milestones for risk-mitigation, including a first-flight of Orbital's Taurus II launch vehicle in December 2011. NASA continues to work actively with its partners to ensure success of the COTS development through completion of demonstration flights and start of commercial resupply services to ISS in FY 2012.

The performance measures below demonstrate the technical challenges that are seen on the development of any major space system and how both NASA and its partners will continue to address these, to head toward success.

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| **Fiscal Year 2010 Performance Improvement** | **Outcome 5.2** | |
| | **Accountable Organization: Exploration Systems Mission Directorate, Constellation Systems** | |
| | By 2010, demonstrate one or more commercial space capabilities for ISS cargo and/or crew transport. | **FY 2010 Yellow** |
| | ***Why Outcome 5.2 was Not Met:*** Both partners, Space Exploration Technologies Corporation (SpaceX) and Orbital Sciences Corporation (Orbital), are making progress in demonstrating their respective transportation capabilities. The partners moved their initial demonstration flights to FY 2011 due to technical issues encountered during development efforts. | |
| | ***FY 2010 Performance Improvement Plan:*** SpaceX is planning for its first ISS demonstration flight in late fall 2010, with remaining flights scheduled for later in FY 2011. Orbital currently is planning its demonstration flight for fall 2011. | |
| | ***Plan Update:*** NASA Commercial Orbital Transportation Services (COTS) partner SpaceX successfully completed their Demonstration 1 mission on December 8, 2010. | |
| **Fiscal Year 2010 Performance Improvement** | **10CS07** | |
| | **Accountable Organization: Exploration Systems Mission Directorate, Constellation Systems** | |
| | In FY 2010, have at least one partner demonstrate flight proximity operations with ISS. | **FY 2010 Yellow** |
| | ***Why Measure 10CS07 was Not Met:*** Both partners, SpaceX and Orbital, made progress in demonstrating their respective transportation capabilities. The partners moved their initial demonstration flights to FY 2011 due to technical issues encountered during development efforts and are continuing toward demonstrating flight operations with ISS in FY 2011. | |
| | ***FY 2010 Performance Improvement Plan:*** The second SpaceX flight, in June 2011, will demonstrate flight proximity operations with ISS. Orbital currently anticipates scheduling its demonstration flight for FY 2012. | |
| | ***Plan Update:*** APG 10CS07 was not completed in FY 2011 due to development challenges. Partner experienced delays as their program transitioned from design to integration and test; however, they continue to make technical progress toward their development and demonstration milestones. These challenges continue to be resolved, and NASA continues to work with our partners. | |

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| Fiscal Year 2010 Performance Improvement | **10CS08** | |
| | **Accountable Organization: Exploration Systems Mission Directorate, Constellation Systems** | |
| | By the end of FY 2010, conduct one or more demonstration flights to, and berth with, the ISS. | **FY 2010 Yellow** |
| | ***Why Measure 10CS08 was Not Met:*** Both partners, SpaceX and Orbital, made progress in demonstrating their respective transportation capabilities. The partners moved their initial demonstration flights to FY 2011 due to technical issues encountered during development efforts and are continuing toward demonstration flights to, and berthing with, ISS in FY 2011. | |
| | ***FY 2010 Performance Improvement Plan:*** SpaceX is planning for its third demonstration flight to, and berth with, ISS in late FY 2011. Orbital currently anticipates scheduling its demonstration flight for FY 2012. | |
| | ***Plan Update:*** APG 10CS08 was not accomplished due to development challenges. Partner experienced delays as their program transitioned from design to integration and test, they both continue to make technical progress toward their development and demonstration milestones. These challenges continue to be resolved, and NASA continues to work with our partners. | |
| Fiscal Year 2011 Performance Improvement | **CS-11-2 (Performance Goal 1.2.1.1)** | |
| | **Accountable Organization: Human Exploration and Operations, Commercial Spaceflight** | |
| | Conduct a minimum of one commercial cargo demonstration flight of proximity operations with ISS. | **FY 2011 Yellow** |
| | ***Why Measure CS-11-2 was Not Met:*** This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones. | |
| | ***FY 2011 Performance Improvement Plan:*** SpaceX and Orbital continue to make progress, mitigating risk and solving technical challenges, and plan a demonstration of proximity operations with ISS in FY 2012. During FY 2011, NASA negotiated additional risk mitigation milestones with each partner. The additional milestones help to improve mission success by (1) augmenting ground and flight testing; (2) accelerating development of enhanced cargo capabilities; or (3) further developing ground infrastructure needed for commercial cargo capabilities. | |
| Fiscal Year 2011 Performance Improvement | **CS-11-3 (Performance Goal 1.2.1.1)** | |
| | **Accountable Organization: Human Exploration and Operations, Commercial Spaceflight** | |
| | Conduct a minimum of one safe berthing of commercial cargo transportation systems with the ISS. | **FY 2011 Yellow** |
| | ***Why Measure CS-11-3 was Not Met:*** This annual performance goal was not met in FY 2011 and is planned to occur in FY 2012. This performance target was not accomplished due to development challenges by NASA's partners. These partners experienced delays as their programs transitioned from design to integration and test, and they both continue to make technical progress toward their development and demonstration milestones. | |
| | ***FY 2011 Performance Improvement Plan:*** SpaceX and Orbital continue to make progress and plan to conduct a minimum of one safe berthing of commercial cargo transportation systems with the ISS in FY 2012. During FY 2011, NASA negotiated additional risk mitigation milestones with each partner to help improve mission success. | |

### Additional Context

**Performance Measure CS-11-1:** *Conduct a minimum of one commercial cargo demonstration flight of new cargo transportation systems* is rated Green. NASA's Commercial Orbital Transportation Services (COTS) partner SpaceX successfully completed its Demonstration 1 mission on December 8, 2010. Further details can be seen at http://www.nasa.gov/home/hqnews/2010/dec/HQ_10-327_SpaceX_Launch.html.

# Human Spaceflight Program Transition

On July 8, 2011, NASA launched the Space Shuttle *Atlantis* (STS-135) as the last mission of the Space Shuttle Program. With the addition of STS-135 to the Space Shuttle launch manifest, the program was extended six months past the target date of retiring the Shuttle by the end of 2010. The delay of the original retirement date caused downrange effects on the transition of hardware, assets, and workforce to new human spaceflight programs.

With the landing of *Atlantis*, NASA was able to begin transition and closeout of the Space Shuttle Program and proceed with the new direction of the Nation's new beyond low-Earth orbit exploration program. In FY 2011, NASA began developing plans for implementing the Space Launch System (SLS) and Multi-Purpose Crew Vehicle (MPCV) projects, including transition of relevant design and developmental activities of the Constellation Program. In September 2011, NASA announced the selection of the new SLS and MPCV designs and is moving forward with transition of applicable work from the Ares and Orion projects toward a first light of the 70-ton SLS vehicle in 2017.

The performance ratings in the table below demonstrate the combined delay of the Space Shuttle Program and the transition to the new programs, with their requisite start-up activities. NASA will strive to meet the goals set forth for MPCV and SLS in the coming years.

| ISS Assembly & Space Shuttle Retirement | | |
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| Fiscal Year 2010 Performance Improvement | **Outcome 1.2** | |
| | **Accountable Organization: Space Operations Mission Directorate, Space Shuttle Program** | |
| | By December 31, 2010, retire the Space Shuttle. | **FY 2010 Yellow** |
| | ***Why Outcome 1.2 was Not Met:*** The rating for 1.2 reflects an adjusted mission schedule that postpones Shuttle retirement activities in response to an Administration policy decision to extend Shuttle flights beyond 2010 to support the completion of the International Space Station. | |
| | ***FY 2010 Performance Improvement Plan:*** Based on the extended mission schedule, NASA plans to retire the Space Shuttle in 2011. | |
| | ***Plan Update:*** NASA completed the Space Shuttle manifest with the launch and landing of STS-135 in July 2011. NASA is executing the plans to display the four remaining orbiters—three operational orbiters and the program's test vehicle—at institutions across the country to inspire the next generation of explorers and engineers. | |
| Fiscal Year 2010 Performance Improvement | **10ISS03** | |
| | **Accountable Organization: Space Operations Mission Directorate, International Space Station Program** | |
| | Per the final configuration agreed to by the International Partners, fly the ISS elements and logistics baselined for FY 2010. | **FY 2010 Yellow** |
| | ***Why Measure 10ISS03 was Not Met:*** Due to technical difficulties and unforeseen delays, NASA was unable to fly all ISS elements and logistics planned for FY 2010. | |
| | ***FY 2011 Performance Improvement Plan:*** Consistent with an Administration policy decision, NASA has revised the Shuttle manifest and related logistics to accommodate the delays experienced in FY 2010 and anticipates ISS completion in FY 2011. | |
| | ***Plan Update:*** The Space Shuttle delivered the final elements of the ISS configuration in FY 2011. | |

| Transitioning Shuttle Assets and Workforce to New Programs | | |
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| Fiscal Year 2010 Performance Improvement | **10SSP03** | |
| | **Accountable Organization: Space Operations Mission Directorate, Space Shuttle Program** | |
| | Complete close-out and transfer plans for all remaining Space Shuttle flight hardware elements and other major Space Shuttle property assets, including the disposition plans for the Orbiters and the means by which significant gaps in human spaceflight operations capabilities will be managed if needed to support future activities. | **FY 2010 Yellow** |
| | ***Why Measure 10SSP03 was Not Met:*** The Agency's decision to extend Space Shuttle flights into 2011 and the uncertainty regarding the future of the Constellation Program caused a delay in finalizing Shuttle asset disposition plans and resolving the human space flight gap. | |
| | ***FY 2010 Performance Improvement Plan:*** Disposition plans for the orbiters will be completed once NASA announces final display locations. NASA plans to resolve funding gaps for human spaceflight capabilities through the FY 2012 budget development process. | |
| | ***Plan Update:*** In April 2011, NASA announced plans to display the four remaining orbiters—three operational orbiters and the program's test vehicle—at institutions across the country to inspire the next generation of explorers and engineers. During FY 2011, NASA focused on finalizing plans to transfer Orbiters to their final display locations. Additionally, NASA released major Space Shuttle operations facilities at the Kennedy Space Center (including the Vehicle Assembly Building and Launch Complex 39-A) for future institutional and programmatic use. | |
| Fiscal Year 2010 Performance Improvement | **10SSP05** | |
| | **Accountable Organization: Space Operations Mission Directorate, Space Shuttle Program** | |
| | With the Constellation Program, complete and deliver one workforce transition strategy report update to Congress in FY 2010. | **FY 2010 Yellow** |
| | ***Why Measure 10SSP05 was Not Met:*** Development of Workforce Transition Strategy reports has been rescheduled pending direction to the Agency following the release of the FY 2011 President's Budget Submit, the proposed transition of the Constellation Program, and identification of future work. In the FY 2011 budget process, the President proposed to Congress that the Constellation Program be transitioned and NASA adjusted its spending on the program consistent with its budget request and with the Appropriation provided by Congress for FY 2010. | |
| | ***FY 2010 Performance Improvement Plan:*** The plan is pending decision of the proposed transition of the Constellation Program. | |
| | ***Plan Update:*** In FY 2010, the Constellation Program was redirected to reflect new Presidential and Congressional direction in NASA's space exploration goals. The new direction called for the start up of the Multi-Purpose Crew Vehicle and Space Launch Systems Programs. Factoring these new programs, and with completion of the Space Shuttle program in July 2011, NASA delivered the Workforce Strategy Report to Congress in September 2011. | |
| Fiscal Year 2011 Performance Improvement | **AMO-11-1 (Performance Goal 5.1.1.1)** | |
| | **Accountable Organization: Mission Support Directorate, Office of Human Capital Management** | |
| | Seventy-five percent or more of Shuttle workforce has been realigned for new Agency needs. | **FY 2011 Yellow** |
| | ***Why Measure AMO-11-1 was Not Met:*** NASA did not meet the target for this annual performance goal as a result of Congressional budget action. The addition of a Shuttle mission and delays in the mission manifest resulted in a slower than planned transition of workforce from the Space Shuttle Program. Additionally, the year-long Continuing Resolution significantly delayed the start of new programs to which NASA planned to transition the Space Shuttle workforce. | |
| | ***FY 2011 Performance Improvement Plan:*** Upon landing of the Space Shuttle *Atlantis* on STS-135 to complete the shuttle program in July 2011, the NASA civil service workforce is being realigned with other Agency priorities. NASA plans to complete this activity in FY 2012. | |

| Formulation of New Human Space Exploration Programs | | |
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| Fiscal Year 2010 Performance Improvement | **10SFS09** | |
| | **Accountable Organization: Space Operations Mission Directorate, Rocket Propulsion Test Program** | |
| | Identify agency rocket propulsion test core capabilities (both infrastructure and critical skills) and maintain them at appropriate levels to be able to meet NASA's current and future rocket testing requirements, and deliver an integrated Agency-level Rocket Propulsion Test Plan that spans the next 10 years and includes DoD and commercial partner requirements and capabilities, as appropriate. | **FY 2010 Yellow** |
| | ***Why Measure 10SFS09 was Not Met:*** The Agency-level Rocket Propulsion Test Plan due date was re-negotiated and agreed upon between NASA and the Office of Management and Budget. The new due date is December 31, 2010. | |
| | ***FY 2010 Performance Improvement Plan:*** The Rocket Propulsion Test Plan is on schedule to meet the December 31, 2010, deadline. | |
| | ***Plan Update:*** The draft Rocket Propulsion Test (RPT) Master Plan was delivered to Headquarters in February 2011. The RPT Master Plan was initially drafted with Constellation Program requirements and had to be revised for the new programs. Due to a delay in identification and incorporation of firm test requirements for the follow-on Space Launch System (SLS), final approval of the Master Plan was not finalized until July 2011. The Rocket Propulsion Test Plan was delivered to Headquarters and signed by the Associate Administrator of the Space Operations Mission Directorate on July 11, 2011. | |
| Fiscal Year 2011 Performance Improvement | **SFS-11-4 (Performance Goal 5.4.2.1)** | |
| | **Accountable Organization: Human Exploration Operations Mission Directorate, 21st Century Ground Systems Program** | |
| | Develop a 21st Century Space Launch Complex (21st CSLC) plan. | **FY 2010 Yellow** |
| | ***Why Measure SFS-11-4 was Not Met:*** This annual performance goal was not met due to a revision on the originally planned schedule for this activity. As is typical with NASA programs and projects in the formulation phase, schedules are expected to change as they are refined heading toward the development phase. As the fiscal year progressed, the maturity of the Human Exploration Capabilities programs increased, and NASA began to work through the significant milestones and associated product development and has settled on the current schedule. Under this schedule, NASA expects that this activity will be completed in the first quarter of FY 2012. | |
| | ***FY 2011 Performance Improvement Plan:*** The 21st Century Ground Systems Program (21CGS) was formally stood up in FY 2011 in accordance with NASA's authorization from Congress, and continues to make progress toward developing its plans to support Exploration Systems Development. Although the 21CGS plan is not officially required until the completion of the Systems Design Review, the draft plan is in the review cycle, with an expected approval in FY 2012. | |

**Additional Context**

**Performance Goal 1.1.1.2:** *HPPG: Safely fly out the Space Shuttle manifest and retire the fleet* is rated Green. This goal achieved all of its FY 2011 targets.

**Performance Measure SSP-11-1:** *Release major Space Shuttle operations facilities at Kennedy Space Center for future institutional and programmatic use.* This goal has been met.

**Performance Goal 5.3.1.1:** *Develop and execute the Rocket Propulsion Test (RPT) Master Plan* is rated Green.

**Performance Measure SFS-11-1:** *Release the Rocket Propulsion Test (RPT) Master Plan* is rated Green. This annual performance goal was met. The Rocket Propulsion Testing Master Plan was signed in July 2011. The plan will be reviewed annually and adjusted according to any evolving requirements and funding availability.

**Performance Goal 1.3.1.1:** *Complete design reviews for Space Launch System (SLS)* is rated Green. New human space flight programs were initiated in fiscal year 2011.

**Performance Measure HEC-11-1:** *Develop top level Agency requirements and draft Program Plan for Space Launch System (SLS)* is rated Green.

**Performance Goal 1.3.1.2:** *Complete design reviews for Multi-Purpose Crew Vehicle (MPCV)* is rated Green.

**Performance Measure HEC-11-2:** *Develop top level Agency requirements and Program Plan for Multi-Purpose Crew Vehicle (MPCV)* is rated Green.

**Performance Goal 5.4.2.1:** *By FY 2014, enable future government and commercial launching and testing from the Florida launch and range complex* is rated Green. Despite delays due to the year long continuing resolution, the top-level requirements were defined and baselined in the Human Exploration Capabilities Requirements Document during 2011, and a draft program plan is in review.

# Scientific Research and Technology Development Process

Scientific research and technology development is an ongoing and fluid business. Often goals are not met because of the dynamic nature of research and technology, which could be impacted by new discoveries, refinement to plans based on new knowledge, new partnerships, a change in priorities, or an optimistic estimate of the pace of future progress into the unknown. The process of creating science or technology generally starts with setting science or research objectives and then finding the "best" performer to contribute toward reaching these objectives, through awarded intramural or extramural efforts. Once awarded, science or research activities begin, and then culminate with a transfer of knowledge or technology placed into an application. Multiple factors can slow the award process, delivery of the scientific or research product, and/or the transition of scientific knowledge or technology for application. For example, delays in the selection process may be caused by delayed availability of funds or a refinement to the solicitation for new ideas, based on a decision to factor new cutting-edge knowledge into the objectives. Additionally, delivery of scientific or research products on original timeframes can be impacted by the availability of a research platform or the discovery that attaining the objectives is unexpectedly complex. NASA's science and research products often depend on vehicle availability for space flight or complex ground-based laboratories, such as a wind tunnel, or the availability of appropriately skilled researchers. Transition of science or technology into an application, can also be impacted by factors in these processes, as well.

NASA's performance measures demonstrated in the table below reflect these various factors and their impact on the planned scientific research and technology development and how the Agency will attempt to mitigate these factors in the coming fiscal year.

| Times to Award Can Be Impacted by Various Factors | | |
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| **Fiscal Year 2010 Performance Improvement** | **Outcome 3E.5** | |
| | **Accountable Organization: Aeronautics Research Mission Directorate** | |
| | For vehicle and propulsion technologies that simultaneously reduce fuel burn, noise, and emissions, by 2016 develop a well-informed trade space, document performance potential, and identify technical risks to a level that enables incorporation of technologies into the design of new aircraft. | **FY 2010 Yellow** |
| | ***Why Outcome 3E.5 was Not Met:*** In addition conducting research through test flights of a hybrid wing body aircraft configuration, NASA sought out additional advanced vehicle concepts from its stakeholders through a solicitation. NASA significantly re-scoped the effort for the NASA Research Announcement (NRA) mid-year, changing the requirements from an advanced vehicle concept study NRA to an advanced vehicle concept study that will develop two concepts to the Preliminary Design Review (PDR) stage. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA is currently negotiating these contracts and expects to announce awards in the first quarter of FY 2011. | |
| | ***Plan Update:*** Three awards were made in the first quarter of FY 2011. Two awards in November 2010, and one in December 2010. This Outcome is (was) back on track to achieve 2016 goals. Note that this Outcome has been revised in both the 2011 Strategic Plan and the FY 2011 Performance Plan. | |
| **Fiscal Year 2010 Performance Improvement** | **10AT12** | |
| | **Accountable Organization: Aeronautics Research Mission Directorate** | |
| | In FY 2010, award a contract to conduct N+2 vehicle systems studies. | **FY 2010 Yellow** |
| | ***Why Measure 10AT12 was Not Met:*** NASA significantly rescoped the effort for the NRA mid-year, changing the requirements from an advanced vehicle concept study NRA to an advanced vehicle concept study that will mature two concepts to PDR stage. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA is currently negotiating these contracts and expects to announce awards in the first quarter of FY 2011. | |
| | ***Plan Update:*** Three awards were made in the first quarter of FY 2011. Two awards in November 2010 and one in December 2010. This work has been accomplished. | |

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| Fiscal Year 2010 Performance Improvement | **10ES20** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 227 days. | **FY 2010 Yellow** |
| | ***Why Measure 10ES20 was Not Met:*** The time within which 80 percent of the Earth Science selection notifications were made decreased in FY 2010 to 231 days, but fell just short of the ultimate goal of 227 days, which it was scheduled to achieve this fiscal year. | |
| | ***FY 2010 Performance Improvement Plan:*** The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. These include the scheduling of proposal due dates to spread out the work for the understaffed research program managers and providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. | |
| | ***Plan Update:*** With the impact of the FY 2011 Continuing Resolution (CR) taken into account, Earth Science showed improvement during FY 2011 by decreasing the time for selection notifications from 231 days to less than 200. (value removes the estimated impact of the extended CR). | |
| Fiscal Year 2010 Performance Improvement | **10HE12** | |
| | **Accountable Organization: Science Mission Directorate, Heliophysics Division** | |
| | Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days. | **FY 2010 Red** |
| | ***Why Measure 10HE12 was Not Met:*** The time within which 80 percent of Heliophysics selection notifications were made increased in FY 2010 to 235 days, exceeding the goal of 215 days. | |
| | ***FY 2010 Performance Improvement Plan:*** The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. These include the scheduling of proposal due dates to spread out the work for the understaffed research program managers and providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. | |
| | ***Plan Update:*** The Heliophysics Division took the steps noted above, and decreased the time within which 80 percent of selection notifications were made to 188 days in FY 2011, surpassing the goal of 207 days. | |
| Fiscal Year 2010 Performance Improvement | **10PS14** | |
| | **Accountable Organization: Science Mission Directorate, Planetary Science Division** | |
| | Reduce time within which 80% of NRA research grants are awarded, from proposal due date to selection, by 5% per year, with a goal of 130 days. | **FY 2010 Red** |
| | ***Why Measure 10PS14 was Not Met:*** The time within which 80 percent of Planetary Science selection notifications were made increased in FY 2010 to 243 days, exceeding the goal of 221 days. | |
| | ***FY 2010 Performance Improvement Plan:*** The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. These include the scheduling of proposal due dates to spread out the work for the understaffed research program managers and providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. | |
| | ***Plan Update:*** With the impact of the FY 2011 Continuing Resolution (CR) taken into account, Planetary Science showed only minimal improvement during FY 2011, decreasing the time for selection notifications from 243 days to approximately 240 days (value removes the estimated impact of the extended CR). | |
| Fiscal Year 2011 Performance Improvement | **ES-11-22 (Efficiency Measure)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Reduce time within which 80 percent of NASA Research Announcement (NRA) research grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days. | **FY 2011 Yellow** |
| | ***Why Measure ES-11-22 was Not Met:*** This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Earth Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 33 days, approximately 16% of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. | |
| | ***FY 2011 Performance Improvement Plan:*** The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. In FY 2012, this will include providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. As the year progresses, other options will also be visited. | |

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| Fiscal Year 2011 Performance Improvement | **PS-11-17 (Efficiency Measure)** | |
| | **Accountable Organization: Science Mission Directorate, Planetary Science Division** | |
| | Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days. | **FY 2011 Red** |
| | ***Why Measure PS-11-17 was Not Met:*** This annual performance target was not met, for the time to complete its grant proposal evaluation and selection process, by the Planetary Science Division, within the Science Mission Directorate. The targeted amount of time was missed by 76 days, approximately 35% of the planned time. The time to award was impacted by the year-long Continuing Resolution, on the order of a 50 day delay, on average, across the Science Mission Directorate. It is estimated that without the impact of the Continuing Resolution, the Planetary Science Division would have missed its target regardless. Other factors contributing to the missed target included staffing transitions in positions key to this process during FY 2011 (new Research and Analysis Lead and new program scientists). The involvement of these scientists in critical mission activities for multiple 2011 launches (Juno, GRAIL, MSL), as well as multiple FY 2011 Announcements of Opportunity also prevented improvement. | |
| | ***FY 2011 Performance Improvement Plan:*** Many of the staffing-level factors seen in FY 2011, that contributed to missing the target, are not expected to be repeated and impact the FY 2012 results. The Science Mission Directorate continues to implement changes to reduce delayed selection notifications. In FY 2012, this will include providing tentative notification to proposers when budget uncertainty (e.g., lack of appropriations, lack of operating plan) delays final decision authority. As the year progresses, other options will also be visited. | |
| **Change Due to New Findings** | | |
| Fiscal Year 2010 Performance Improvement | **10AT02** | |
| | **Accountable Organization: Aeronautics Research Mission Directorate** | |
| | Develop an atomistically-based model capable of predicting within 25% the degradation caused by environmental effects on interfaces in selected polymer matrix composite materials. | **FY 2010 Yellow** |
| | ***Why Measure 10AT02 was Not Met:*** This effort attempted to significantly push the state-of-the-art in atomistic-based computational modeling, and application of such models to predict the effects of aging of epoxy matrix resins used on commercial aircraft. The computational model that was developed predicted a reduction in surface energy over time, which is consistent with physical aging phenomenon reported in the literature. While the surface energy predictions differed somewhat from the measured values, experiments on lap shear specimen data for both surface energy and lap shear strength validated the predicted trends. Due to variability in computational and experimental results, it was not possible to validate the computational model for accurate quantitative prediction of physical aging to the performance level defined in the green success criteria. | |
| | ***FY 2010 Performance Improvement Plan:*** The activity as defined in the APG is complete The performance level defined in the yellow success criteria was achieved. Since this was a “stretch-goal” no plans exist to continue to attempt to reach the absolute accuracy reflecting a green success criteria. However, the results obtained will inform future research in atomistic computational modeling. Further, successful prediction of the trends observed in experiments show that atomistic computational modeling may indeed be a valuable tool to guide new material development for improved durability. | |
| | ***Plan Update:*** No further activity is planned. | |

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| **Availability of Research Facilities** | | |
| Fiscal Year 2010 Performance Improvement | **10AC12** | |
| | **Accountable Organization: Exploration Systems Mission Directorate, Advanced Capabilities** | |
| | Demonstrate one year of experimental operation of the Vehicle Cabin Atmosphere Monitoring (VCAM) system on orbit. | **FY 2010 Yellow** |
| | ***Why Measure 10AC12 was Not Met:*** NASA delivered and installed the VCAM in FY 2010. To date, the instrument has operated successfully; however, due to delays in the Space Shuttle launch schedule this instrument was not in place in time to demonstrate a full year of operation by the close of the fiscal year, per the annual performance goal. | |
| | ***FY 2010 Performance Improvement Plan:*** The VCAM is fully functional and on track for reaching one year of experimental operation in March 2011. | |
| | ***Plan Update:*** In May 2011, the VCAM successfully completed one year of operations onboard the ISS. An independent assessment of the VCAM’s performance validated its technical capabilities. | |

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| Fiscal Year 2010 Performance Improvement | **10AT10** | |
| | **Accountable Organization: Aeronautics Research Mission Directorate** | |
| | Complete CFD predictions of ramjet-to-scramjet mode-transition and compare to wind tunnel and/or X-51 flight test data. | **FY 2010 Yellow** |
| | ***Why Measure 10AT10 was Not Met:*** NASA delayed this work into FY11 due to Air Force X-51 flight delays. NASA received the data from the first flight on May 26, 2010, in August 2010. The next flight (second of four) is scheduled for the December 2010 through January 2011 time period. The data from the remaining X-51 flights is required to meet APG. The APG completion date estimate has been revised to September 2011. | |
| | ***FY 2010 Performance Improvement Plan:*** Information from remaining flights of Air Force X-51 required to achieve this APG. | |
| | ***Plan Update:*** Information from the remaining flights of Air Force X-51 are required to achieve this APG. The second flight of the X-51A was attempted June 13, 2011. However, the flight test failed due to the failure of scramjet to operate. The X-51 test flight team is continuing to review the flight data to determine the cause of the failure. As such, the schedules for X-51 flights 3 and 4 are unknown at this time. NASA will conduct the CFD comparisons with the flight test data and achieve this annual performance goal, once all data has been received from successful flight tests of the X-51A. | |
| Fiscal Year 2011 Performance Improvement | **AR-11-9 (Performance Goal 4.1.3.1)** | |
| | **Accountable Organization: Aeronautics Research Mission Directorate** | |
| | Validate NASA propulsion Computational Fluid Dynamics (CFD) codes using Hypersonic International Flight Research Experimentation (HIFiRE) scramjet flight data and ground-based test results. | **FY 2011 Yellow** |
| | ***Why Measure AR-11-9 was Not Met:*** This annual performance goal was not met, in this fiscal year, and is expected to be accomplished in the June/July 2012 timeframe. To validate the Computational Fluid Dynamics (CFD) code, NASA is gathering this data on the Hypersonic International Flight Research Experimentation (HIFiRE) #2 vehicle's scramjet, while in flight. The Air Force has moved the date for the HIFiRE #2 vehicle launch until Summer 2012. | |
| | ***FY 2011 Performance Improvement Plan:*** This goal will be considered complete once code validation occurs using the flight data when available, following the successful launch of the HIFiRE #2. | |
| Fiscal Year 2011 Performance Improvement | **AR-11-12 (Efficiency Measure)** | |
| | **Accountable Organization: Aeronautics Research Mission Directorate** | |
| | Deliver at least 86 percent of on-time availability for operations and research facilities. | **FY 2011 Yellow** |
| | ***Why Measure AR-11-12 was Not Met:*** The on-time availability of the operations and research facilities managed by the Aeronautics Test Program, was 80%, slightly less than the targeted 86% availability. NASA did not meet its target, primarily due to the downtime, introduced with the failure of subsystems in two facilities at the Glenn and Langley Research Centers. At Glenn Research Center, the 8 foot by 6 foot Wind Tunnel, had unscheduled downtime to repair the Open Rotor Propulsion Rig (ORPR) forward balance, which has resulted in rescheduling testing into FY 2012. At Langley Research Center, the 14 foot by 22 foot Wind Tunnel experienced unscheduled downtime due to issues with the main drive lubrication system and the motor generator set. | |
| | ***FY 2011 Performance Improvement Plan:*** In FY 2011, the Aeronautics Test Program (ATP) Capability Investment project manager initiated a new set of facility assessment actions which will provide the program with updated information on the condition of the tunnel infrastructure and sub-systems. To date, five assessments have been completed and six additional assessments are scheduled to begin at the end of this fiscal year. The updated condition information will potentially allow the ATP program to identify and resolve critical maintenance issues before they impact customer testing schedules. | |

### Additional Context

**Performance Measure HE-11-9:** *Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days* is rated Green. This annual performance goal was met. The Heliophysics Division within the Science Mission Directorate has met its annual target for time to complete its grant proposal evaluation and selection process.

**Performance Measure AS-11-9:** *Reduce time within which 80 percent of NASA Research Announcement (NRA) grants are awarded, from proposal due date to selection, by four percent per year, with a goal of 180 days* is rated Green. This annual performance goal was met. The Astrophysics Division within the Science Mission Directorate has met its annual target for time to complete its grant proposal evaluation and selection process.

# Baseline Cost and Schedule Changes

NASA's projects are generally high-risk, one-of-a-kind space flight mission developments that usually do not enter an "operational" or production state. Estimating cost and schedule baselines for these types of projects is complex and challenging, with many factors that introduce risk and must be accounted for. Risks can be introduced based on factors in the industrial base such as launch vehicle availability, an absence of needed vendor capabilities, and/or counterfeit parts. An instability of funding, delays in funding, or a misalignment of resources, which is estimated to be needed in a specified timeframe, can significantly contribute to cost and schedule growth. Additionally, various acquisition challenges, such as protests on a vendor award, can impact project costs and schedule baselines. Ineffective project planning and controls can impact the ability to understand these factors and to address them in a manner to either recognize or mitigate cost and schedule growth. Specifically, effective lifecycle cost and schedule management requires:

- Good lifecycle cost-estimating policy and processes (sets good baselines).
- Institution of tracking and trending methodologies and using "best practice" tools to predict life-cycle estimate changes (proactively predicts baseline drift and violation of that baseline).
- Effective risk identification, and planning for the costs to mitigate and deal with these risks if they manifest (manages threats to life-cycle cost/schedule changes).
- Clear reporting requirements and responsibilities (ensures accountability).
- Making budget planning and allocation decisions based on lifecycle cost and schedule estimates and the performance toward these (ensures alignment of funding needs to lifecycle needs).

Since 2005, the Agency has taken many steps to make progress in this complex area, including new estimating processes, setting new policies to better align budgeting with cost estimation, and reports on both a quarterly and annual basis to the Office of Management and Budget and U.S. Congress, respectively, ensuring accountability and transparency. NASA continues to build on each step toward improving cost and schedule performance.

NASA began a new cost and schedule estimation initiative, joint cost and schedule confidence levels (JCL), to increase the likelihood of project success at the specified funding level. The application of the JCL process is expected to increase the insight of project and program managers and others into uncertainties and contingencies within an integrated cost and schedule plan. NASA is taking steps in the early (formulation) stages of projects to ensure appropriate technical risk reduction and is actively refining the cost ranges for projects in formulation to improve budget estimates as these projects make their way through Phases A and B. Projects in development are budgeted to a Life Cycle Cost reflecting a 70 percent cost confidence level (CCL) or, more conservatively, a JCL. In conjunction with the JCL initiative, NASA issued an Interim Directive to the *NASA Procedural Requirements 7120.5D: Space Flight Program and Project Management Requirements*. This interim directive strengthened and clarified the existing program and project management requirements regarding cost and schedule baselining and rebaselining policy.

NASA enhanced acquisition policies and procedures. One main policy element introduced was to base acquisition on an expanded view of cost and schedule risks realistic cost estimates and achievable schedules, and to confirm this on an annual basis. This includes incorporating a risk-informed acquisition process that provides an integrated and holistic view of risk, including Agency-level, institutional, and program/project. A more holistic view of risk helps to better match the stakeholder expectations and the "true" resources required to address the risks and achieve those expectations. An integrated perspective of risks and aids for analyzing competing decision alternatives can help appropriately apply funds.

NASA also increased its oversight and surveillance, on programs and projects as well as procurements. The construct for performance reviews was modified to ensure that at key decision points, in-depth independent reviews were conducted, paired with ongoing surveillance in between. Programs and projects are both subjected to episodic independent reviews, conducted by Standing Review Boards, at key points in the life cycle. Monthly or quarterly senior management reviews will assess ongoing programmatic and institutional performance and identify crosscutting issues. To aid in both program/project and contractor surveillance and oversight, Agency earned value management (EVM) capabilities and capacity are being increased. NASA decided to build an Agency-wide capability to effectively use EVM on in-house efforts and to provide an integrated contractor and in-house EVM reporting capability. The latter process is expected to be rolled out initially on the Ice, Clouds, and Land Elevation Satellite (ICESat)-II and Space Launch System projects.

NASA will continue to follow through with the new policies, procedures, and management attention on cost and schedule growth in the coming year, with the goal of improving the Agency's future performance.

| | | |
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| Fiscal Year 2010 Performance Improvement | **10IT11** | |
| | **Accountable Organization: Office of the Chief Information Officer** | |
| | Complete all development projects within 110% of the cost and schedule baseline. | FY 2010 Red |
| | ***Why Measure 10IT11 was Not Met:*** All but one project finished within the required 110 percent of cost and schedule baselines. The Security Operations Center (SOC) implementation (Phase-2) project has undergone schedule slips, due to delays in facilities power modifications resulting in delays of receiving IT Security event data from numerous sources across the Agency. The delay in having adequate power to the facility kept the SOC from being able to capture data, thereby not allowing testing and not being ready to complete the ORR. The extra power lines and resultant coordination were not planned for when the project was initially scoped and were beyond the initial project plan estimates. The final SOC implementation plan will increase cost to 145 percent and schedule to 161 percent of the initial project scope. NASA reviewed this project during implementation, and given the importance of IT security, approved additional time and funding for the project. | |
| | ***FY 2010 Performance Improvement Plan:*** There are no options to achieving this goal. NASA determined the IT Security Operations Center project implementation fits into the CyberSecurity scope and needed to be accomplished to protect NASA's IT vulnerability. | |
| | ***Plan Update:*** N/A | |
| Fiscal Year 2010 Performance Improvement | **10HE09** | |
| | **Accountable Organization: Science Mission Directorate, Heliophysics Division** | |
| | Complete all development projects within 110% of the cost and schedule baseline. | FY 2010 Red |
| | ***Why Measure 10HE09 was Not Met:*** NASA did not complete the Solar Dynamics Observatory (SDO) within 110 percent of cost and schedule baselines. SDO initially slipped from its 2008 firm slot in the launch manifest due to late delivery of avionics boxes and instruments and problems with electronics parts and the high-speed data bus. SDO then experienced difficulty obtaining a new slot in the launch manifest, as no firm slots were available until 2010 due to multiple Atlas V launch vehicle issues and associated launch queue delays. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA launched SDO in February 2010. This exceeded the original schedule by 48 percent, but the mission's lifecycle cost remains within seven percent of the original cost baseline. | |
| | ***Plan Update:*** N/A | |
| Fiscal Year 2010 Performance Improvement | **10ES17** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Complete all development projects within 110% of the cost and schedule baseline. | FY 2010 Red |
| | ***Why Measure 10ES17 was Not Met:*** NASA did not complete the Glory and Aquarius missions within 10 percent of their cost and schedule baselines. | |
| | ***FY 2010 Performance Improvement Plan:*** The Glory mission experienced significant cost and schedule growth due primarily to the failure of the Orbiting Carbon Observatory (OCO) Taurus XL launch vehicle and issues with the vendor's production of acceptable boards for the Maxwell Single Board Computers. Glory's current projected lifecycle cost is 68 percent higher than the baseline established at Confirmation Review. The mission is tentatively scheduled for a February 2011 launch readiness date, a 72 percent increase in schedule. The Aquarius launch readiness date has been rescheduled for April 2011 due to delays in the development of the international partner's Mission Operations System. The schedule for the mission has increased by 60 percent, but the lifecycle cost remains within 15 percent of the baseline. | |
| | ***Plan Update:*** N/A | |
| Fiscal Year 2011 Performance Improvement | **ES-11-19 (Efficiency Measure)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Complete all development projects within 110 percent of the cost and schedule baseline. | FY 2011 Red |
| | ***Why Measure ES-11-19 was Not Met:*** This annual performance goal was not met, due to cost and schedule growth that exceeded 10 percent of their estimated baseline for the NPOESS Preparatory Project (NPP), Glory, and Aquarius missions. The NPP mission experienced delays due to the restructure of the project management and on-going development issues with an instrument, contributed by one of NASA's partners. The Aquarius mission was delayed by NASA's international partner, after the successful delivery of NASA's instrument contribution. The Glory mission had both instrument and spacecraft technical issues, across its development. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA's new 70 percent CL requirements include consideration of the risks of partnership. These and other procedures subsequently put in place are improving cost and schedule performance. | |

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| **Development Partner Challenges** | | |
| **Fiscal Year 2010 Performance Improvement** | **10ES02** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Develop missions in support of this Outcome, as demonstrated by completing Aquarius Operational Readiness Review (ORR). | **FY 2010 Yellow** |
| | ***Why Measure 10ES02 was Not Met:*** Due to delays in the development of the international partner's Mission Operations System, the ORR was not completed in FY 2010. | |
| | ***FY 2011 Performance Improvement Plan:*** A specific date has not been identified, but NASA estimates this to be in early 2011. However, any delays to the overall mission schedule could cause the ORR to move further. | |
| | ***Plan Update:*** The Aquarius Operational Readiness Review was completed April 28, 2011. | |
| **Vendor Quality Parts and Processes** | | |
| **Fiscal Year 2010 Performance Improvement** | **10ES21** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Develop missions in support of this Outcome, as demonstrated by completing the Pre-Ship Comprehensive Performance Test for Glory. | **FY 2010 Yellow** |
| | ***Why Measure 10ES21 was Not Met:*** The Glory Pre-Ship Comprehensive Performance Test began on September 17, 2010, but was not completed until October 4, 2010. The test was delayed primarily due to resolution of spacecraft hardware anomalies. | |
| | ***FY 2010 Performance Improvement Plan:*** The test was completed successfully on October 4, 2010. | |
| **Fiscal Year 2010 Performance Improvement** | **10AS07** | |
| | **Accountable Organization: Science Mission Directorate, Astrophysics Division** | |
| | Develop missions in support of this Outcome, as demonstrated by completing the first competed Early Science observations on the Stratospheric Observatory for Infrared Astronomy (SOFIA). | **FY 2010 Yellow** |
| | ***Why Measure 10AS07 was Not Met:*** Technical problems with the telescope cavity door actuator on the SOFIA aircraft, due to quality control issues at the vendor of the actuator, led to increased time required for flight testing and certification for open-door flight at the altitude required for Early Science. NASA worked directly with the vendor to address and resolve the quality control issues. | |
| | ***FY 2010 Performance Improvement Plan:*** Flight testing of the full flight envelope has been completed, and the first image has been acquired by the telescope in flight. The program is currently on track for the first Early Science observation by December 2010. | |
| | ***Plan Update:*** SOFIA completed the first of three science flights on Wednesday, December 1, 2010. | |
| **Fiscal Year 2011 Performance Improvement** | **ES-11-3 (Performance Goal 2.1.1.2)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Initiate the Orbiting Carbon Observatory-2 (OCO-2) Instrument and Spacecraft System-Level Testing. | **FY 2011 Yellow** |
| | ***Why Measure ES-11-3 was Not Met:*** The OCO-2 instrument system-level testing was scheduled to begin in August 2011, but has been delayed to October due to technical issues. Technical issues included a coating adhesion issue on multiple parts that was introduced by contamination during the vendor's process, and a misalignment along an optical path on the instrument, which was seen during vibration testing and could impact performance. Additionally, the spacecraft-level system testing is scheduled to begin in December 2011, due to late deliverables from subsystem vendors. At this time, the overall delivery of the spacecraft remains unchanged for March 2012, but the instrument delivery has been delayed by one month to April 2012, and NASA continues to work with its vendors to address these issues and prevent further delays. | |
| | ***FY 2011 Performance Improvement Plan:*** To address the coating adhesion issue, a decision was made to proceed with an alternate vendor and process (black anodizing) for the parts. The change was implemented and all parts now meet specification. Additionally, the optical path misalignment issue was addressed and appears to be resolved, but it will remain open until confirmed during instrument-level vibration testing (scheduled for December 2011). These two issues have resulted in an approximately a one month delay in delivery of the instrument (now April 2012). This delay is not expected to impact the overall delivery schedule of the observatory or the launch readiness date (LRD). The Spacecraft System-Level Testing has been scheduled for December 2011 due to the late subsystem vendor deliveries. However, the spacecraft remains on plan to be delivered in March 2012, with no impact to the Launch Readiness Review. | |

| Fiscal Year 2011 Performance Improvement | | |
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| | **ES-11-6 (Performance Goal 2.1.2.2)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Complete the Global Precipitation Mission (GPM) Systems Integration Review | **FY 2011 Yellow** |
| | ***Why Measure ES-11-6 was Not Met:*** Both the NASA spacecraft and instrument developments are experiencing challenges in subsystem deliveries. These development challenges are resulting from various issues including defects discovered in flight parts, component manufacturing throughput issues and workmanship issues at supply vendors. In addition, the delivery of the JAXA (Japanese space agency)-provided Dual Precipitation Radar (DPR) instrument has been delayed due to disruptions at, and damage to, the test facility resulting from the March 2011 earthquake. Technical issues with the DPR were also identified during environmental testing. It is currently estimated that these challenges will result in a launch readiness delay of eleven months, from July 2013 to June 2014. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA and JAXA are working together to replan the program to accommodate these delays. NASA and JAXA have taken actions that include implementing extended shifts/weekend work and integration and testing workarounds (for NASA, the use of engineering test units in place of flight subsystems) to recover schedule where feasible. Completion of the Systems Integration Review is scheduled for the second quarter of FY 2012. | |

| **Launch Vehicle Availability & Reliability/Manifest Issues** | | |
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| Fiscal Year 2010 Performance Improvement | **10ES10** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Develop missions in support of this Outcome, as demonstrated by completing the SMAP Preliminary Design Review (PDR). | **FY 2010 Yellow** |
| | ***Why Measure 10ES10 was Not Met:*** The Soil Moisture Active and Passive (SMAP) mission PDR is currently scheduled for March 2011, consistent with the schedule presented at the mission's Initial Confirmation Review. | |
| | ***FY 2010 Performance Improvement Plan:*** Currently, all pre-cursor events (i.e., peer reviews, sub-system PDRs) are proceeding on or ahead of plan. However, a launch vehicle has not yet been selected for SMAP, and this could impact the scheduling of the PDR. NASA is addressing this issue, but it is not expected to be resolved until after March. | |
| | ***Plan Update:*** The Prelminary Design Review for the SMAP mission occurred in October 2011. | |
| Fiscal Year 2011 Performance Improvement | **ES-11-10 (Performance Goal 2.1.4.2)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Complete the Soil Moisture Active-Passive (SMAP) Confirmation Review. | **FY 2011 Yellow** |
| | ***Why Measure ES-11-10 was Not Met:*** The SMAP Confirmation Review was delayed to FY 2012 because of difficulties in identifying an acceptable launch vehicle for the mission. NASA's Earth Science program has been impacted by the current limited availability of launch vehicles in the medium size range that is appropriate for most of its missions. | |
| | ***FY 2011 Performance Improvement Plan:*** The SMAP Confirmation Review has been rescheduled until the second quarter of FY 2012. The Science Mission Directorate (SMD) plans to conduct a Directorate-level Program Management Council (DPMC) review in November 2011 to assess project status and establish near-term observatory development guidelines and constraints following the recent Preliminary Design Review. To conduct the PDR, SMD management requested the project assume use of a Minotaur IV+ launch vehicle. This DPMC will also assess a plan to establish a project baseline cost and schedule, that is independent of a confirmed launch vehicle (which is not expected until mid 2012). This plan forward will consider analysis of observatory design, cost and schedule risks, and any additional required reviews. In parallel with these activities, SMD will continue to work with the Human Exploration and Operations Directorate to pursue launch vehicle options for SMAP. | |

| Funding Instability | | |
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| Fiscal Year 2011 Performance Improvement | **ES-11-14 (Performance Goal 2.1.5.3)** | |
| | **Accountable Organization: Science Mission Directorate, Earth Science Division** | |
| | Complete the ICESat-2 Spacecraft System Requirements Review. | **FY 2011 Yellow** |
| | ***Why Measure ES-11-14 was Not Met:*** The date for the ICESat-2 Spacecraft Systems Requirements Review has been delayed to December 2011. This review was rescheduled from March 2011 to revisit the mission design and requirements to align with the estimated available budget, moving forward. | |
| | ***FY 2011 Performance Improvement Plan:*** The mission design and requirements have been revised to align to the available funds. As part of the realignment, the mission is moving forward based on a co-manifested launch solution, with shared launch costs, with the Air Force. The Spacecraft System Requirements Review is scheduled for December 2011. The mission's baseline plan is to be manifested with the Defense Meteorological Satellite Program Flight-20 (DMSP F-20) on an Atlas V launch vehicle that has already been purchased by the U.S. Air Force (USAF). NASA will be responsible for funding the Dual Spacecraft System (DSS) development and flight unit qualification. The DSS will represent a new capability for U.S. government payloads using the EELV launch system. The USAF will procure the launch service and provide overall mission assurance related to the launch vehicle and dual payload accommodation. This interagency arrangement provides significant cost savings for NASA, allowing the mission to proceed within its allocated budget. | |

| Program Planning and Controls | | |
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| Fiscal Year 2010 Performance Improvement | **10IT06** | |
| | **Accountable Organization: Office of the Chief Information Officer** | |
| | Complete Operational Readiness Review (ORR) for the NASA Security Operations Center. | **FY 2010 Red** |
| | ***Why Measure 10IT06 was Not Met:*** The Security Operations Center (SOC) Implementation Project was scheduled to have the ORR this year, but has undergone schedule slips due to delays in facilities power modifications and further delays in receiving IT Security data from numerous sources across the Agency. These delays have negated the ability to complete the testing required in preparation of the Operational Readiness Review. | |
| | ***FY 2010 Performance Improvement Plan:*** The SOC Implementation Project will move forward with IT Security event data collection in fall 2010. As the data is obtained, the project will complete final system integration and validation testing. Upon completing validation testing and user training the project will precede to ORR currently scheduled for November FY 2011. | |
| | ***Plan Update:*** The SOC ORR was completed March 2011. | |
| Fiscal Year 2010 Performance Improvement | **10SFS07** | |
| | **Accountable Organization: Space Operations Mission Directorate, Space and Flight Support** | |
| | Complete TDRS K/L Project Mission Operations Review (MOR). | **FY 2010 Yellow** |
| | ***Why Measure 10SFS07 was Not Met:*** The TDRS project had originally scheduled the K/L MOR for September 2010 but was delayed to resolve minor conflicts involving resources. | |
| | ***FY 2010 Performance Improvement Plan:*** The MOR will be held in November 2010. | |
| | ***Plan Update:*** The Mission Operations Review was held in November 2010. | |
| Fiscal Year 2010 Performance Improvement | **10PS06** | |
| | **Accountable Organization: Science Mission Directorate, Planetary Science Division** | |
| | Develop missions in support of this Outcome, as demonstrated by completing the Mars Science Laboratory (MSL) flight hardware builds and flight system assemblies. | **FY 2010 Yellow** |
| | ***Why Measure 10PS06 was Not Met:*** The flight hardware build and flight system assembly of the Sample Analysis at Mars (SAM) instrument were not completed during the designated fiscal year, due to complications in the development of the Wide Range Pump (WRP) components of the instrument. The materials originally specified as the primary component of a high-speed, high-performance bearing proved to be inadequate to provide the necessary performance on the surface of Mars, and alternative bearing materials and components had to be researched and developed. | |
| | ***FY 2010 Performance Improvement Plan:*** The development of the new bearing designs has been completed and implemented, and the finalization of the flight hardware build has resumed. The final flight units are on schedule to be delivered in early December 2010. | |
| | ***Plan Update:*** The work was completed by redesigning the primary bearings on the pump from alternate materials that provided the required performance for the Mars environment. Design, fabrication, testing, validation, and installation of the new bearings was completed according to the revised schedule. The pump was completed and delivered to the flight project as scheduled in December 2010. | |

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| Fiscal Year 2011 Performance Improvement | **Performance Goal 2.4.2.2** | |
| | **Accountable Organization: Science Mission Directorate, James Webb Space Telescope Program** | |
| | Design and assemble James Webb Space Telescope (JWST). | **FY 2011 Yellow** |
| | ***Why Performance Goal 2.4.2.2 was Not Met:*** The measure was placed in the FY 2012 Congressional Justification prior to the project's replan. Based on this, the baseline assumption for the measure was that the project was still operating under the original baseline. The new estimated baseline, which was approved late in the fiscal year, resulted in a 78% increase in the estimated life cycle cost from the original baseline. The new estimated baseline has been endorsed by the NASA Administrator, all reporting required by Section 103 of the NASA Authorization Act of 2005 has been completed, and 95% of the FY 2011 planned activities were accomplished, indicating that it is likely to stay on track for the new estimated cost. Specifically, JWST achieved 19 of its 21 planned FY 2011 milestones on or ahead of schedule, one milestone was achieved one month late and one milestone was delayed due to design changes, and is on track to achieve its FY 2012 milestones. The one planned FY 2011 milestone that was achieved a month late and the one that has been delayed do not impact the critical path. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA has taken many steps to address the challenges seen on the JWST Project. In FY 2010, an independent panel concluded that the problems causing cost growth and schedule delays on the JWST project were associated with cost estimation and program management. To address these, NASA made several important changes in JWST program and project management and in the interaction with the prime contractor. All the JWST senior management at both Headquarters and at Goddard Space Flight Center have been replaced. The program has been taken out of the Astrophysics Division and now reports programmatically to the NASA Associate Administrator, and is an Agency priority. NASA also embarked on revising the cost and schedule estimates. The replanning activity is complete, has been approved within the Agency. The Agency will continue to monitor the progress on the development of this project, as highlighted above. | |
| **Acquisition Management Challenges** | | |
| Fiscal Year 2010 Performance Improvement | **10SFS08** | |
| | **Accountable Organization: Space Operations Mission Directorate, Space Communications and Navigation** | |
| | Complete SN Ground Segment Sustainment project (SGSS) Mission Definition Review. | **FY 2010 Yellow** |
| | ***Why Measure 10SFS08 was Not Met:*** The SGSS Mission Definition Review did not occur as planned due to an ongoing contractor protest. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA will develop a new plan and schedule for completing the Mission Definition Review once the protest is adjudicated. | |
| | ***Plan Update:*** The SGSS contract award was upheld in FY 2011. After the contract was initiated, it was determined that dividing the Mission Definition Review into two parts, with the first part focused on the technical review, and the second part focused on budget, was the appropriate approach. The technical review, which was very successful, was held in July 2011; the second review is scheduled to be held in December 2011. | |
| Fiscal Year 2010 Performance Improvement | **10PS05** | |
| | **Accountable Organization: Science Mission Directorate, Planetary Science Division** | |
| | Develop missions in support of this Outcome, as demonstrated by selecting concept studies for the Discovery 12 mission. | **FY 2010 Yellow** |
| | ***Why Measure 10PS05 was Not Met:*** The acquisition timeline for the Discovery 12 mission was extended due to the complexity of the Announcement of Opportunity, which includes the potential use of radioisotope power systems. | |
| | ***FY 2010 Performance Improvement Plan:*** Twenty-eight proposals have been received. Selection of concept studies is scheduled for mid-FY 2011. | |
| | ***Plan Update:*** In May 2011, NASA selected three mission concepts (GEMS, TiME, and Comet Hopper) for study from the 28 proposals received. After a detailed review of the three concept studies in 2012, one will be selected as the 12th Discovery Program mission. | |

| Fiscal Year 2011 Performance Improvement | AMO-11-12 (Performance Goal 5.2.2.1) | |
|---|---|---|
| | **Accountable Organization: Office of the Chief Information Officer** | |
| | Achieve Initial Operating Capability (IOC) for five Service Offices (Web Services, Communications, Enterprise Service Desk, End User Services, and NASA Enterprise Applications) as part of the NASA Information Technology Infrastructure Integration Program (I3P). | **FY 2011 Yellow** |
| | ***Why Measure AMO-11-12 was Not Met:*** Four of the five planned service offices achieved Initial Operating Capability (IOC). The End User Services (ACES), Enterprise Applications (EAST), Enterprise Service Desk (ESD), and Communications (NICS–Networking) services all have their office structures in place, are managing the transition to these new services, and continue to operate the current services. The one service office that did not reach IOC in FY 2011 is the one for the Web services (WEST). The implementation of this initiative has been delayed to resolve some issues with the contract award. NASA remains on track for the consolidation and centralization of these services and capabilities by 2014. | |
| | ***FY 2011 Performance Improvement Plan:*** NASA will continue to work through the issues with the contract award of the web services capability. The implementation of the WEST will be revisited once these issues are resolved. | |

**Additional Context**

**Performance Measure ES-11-2:** *Complete the Aquarius Launch Readiness Review* is rated Green. The Launch Readiness Review was completed on June 7, and Aquarius was successfully launched on June 10, 2011.

**Performance Measure JWST-11-1:** *Complete new James Webb Space Telescope (JWST) mission re-baseline* is rated Green. The JWST project completed its rebaseline in September, and information on the new estimated cost and schedule, has been provided to both the Congress and OMB.

# Workforce, Workplace, and Diversity

NASA values its workforce and strives to improve its productive environment. The ultimate goal is to ensure the workplace allows employees from diverse backgrounds, ethnicities, and genders to reach their potential and contribute to NASA's mission. Multiple offices work together, to this end, including the Office of Human Capital Management, the Office of Diversity and Equal Opportunity, and the Office of Education. The latter office contributes to developing a national science, technology, engineering, and mathematics (STEM) workforce, one that NASA can draw upon to meet its hiring needs.

The performance measures below demonstrate NASA's efforts to continually improve the workforce environment, for all employees through multiple initiatives, and to influence a STEM pipeline, with diverse populations to draw upon for hiring needs. Multiple factors can impact these efforts, including funding delays, imperfect data collection methods, and receiving changes to priorities mid-year from the Administration or Congress. In the case of several of these measures, NASA performance is trending well, but the original targets were aggressive, which is demonstrated by the rating.

<table>
<tr><th colspan="3">Continual Improvement of the Workforce Environment</th></tr>
<tr><td rowspan="4">Fiscal Year 2011<br>Performance Improvement</td><td colspan="2">AMO-11-6 (Performance Goal 5.1.1.4)</td></tr>
<tr><td colspan="2">Accountable Organization: Mission Support Directorate, Office of Human Capital Management</td></tr>
<tr><td>Identify and address at least two topics that employees identified in the latest Federal Employee Viewpoint Survey.</td><td rowspan="3">FY 2011<br>Yellow</td></tr>
<tr><td>Why Measure AMO-11-6 was Not Met: This annual performance goal was not met. Many of the planned activities were completed but several have been delayed into FY 2012. Specifically, the identified areas to be addressed, and their corresponding action plan, are as follows:<br><br>1) Continue focus on teamwork/working together to ensure mission success. Planned actions included continual monitoring of Shuttle workforce concerns through regular surveys; and instituting a team-building focus in Agency leader development programs. The activities toward this topic were completed in this fiscal year.<br><br>2) Ensure that recognition and rewarding of employees is fair, consistent, and based on results-oriented performance. The planned actions included educating and training supervisors, through Agency supervisory training courses; and implementing recommendations for enhancing the Agency's Honor Awards Program. Both of these planned actions were delayed into FY 2012. This year's funding level removed the option for conducting further Agency supervisory courses in FY 2011. Additionally, the development of new policies surrounding the Agency Honor Awards Program, is taking more time than planned, resulting in a delay until FY 2012.</td></tr>
<tr><td>FY 2011 Performance Improvement Plan: These actions will be completed in fiscal year 2012. OHCM will continue focus on teamwork and working together to ensure mission success. Actions include continual monitoring of Shuttle workforce concerns through regular surveys; and team-building focus in Agency leader development programs. OHCM will also ensure that recognition and rewarding of employees is fair, consistent, and based on results-oriented performance. Actions include educating and training supervisors through Agency supervisory training course and to implement recommendations for enhancing the Agency's Honor Awards Program.</td></tr>
<tr><td rowspan="4">Fiscal Year 2011<br>Performance Improvement</td><td colspan="2">AMO-11-7 (Performance Goal 5.1.1.5)</td></tr>
<tr><td colspan="2">Accountable Organization: Office of Diversity and Equal Opportunity</td></tr>
<tr><td>Complete FY 2011 actions described in the NASA Model Equal Employment Opportunity (EEO) Agency Plan.</td><td rowspan="3">FY 2011<br>Yellow</td></tr>
<tr><td>Why Measure AMO-11-7 was Not Met: NASA made significant progress on many of 57 activities, contained in the Model EEO Agency Plan for FY 2011-2013, which have efforts in fiscal year 2011, but did not complete all the planned actions. NASA sought to complete 40 of the 57 actions in the first year of the Plan alone. NASA completed 14 of these actions (35 percent). In addition, NASA completed five actions not targeted for completion until FY 2012. Of the other actions targeted for completion in FY 2011, NASA has partially completed 19 (48 percent). NASA has completed key actions related to the Agency's Anti-Harassment Program, Conflict Management Program, and the Functional Review Program is on track for completion of its actions. However, as a result of recent Executive Orders that required development of action plans in FY 2010-2011 for Asian Americans and Pacific Islanders, Individuals with Disabilities, and Veterans, NASA had to add multiple actions to the Model EEO Agency Plan. The initial development of these plans, dispositioning of community group comments, and introduction of approximately 20 new actions, mid-year, did not allow time for full progress to be made. All efforts continue to progress, and are expected for completion before the end of the plan's timeframe.</td></tr>
<tr><td>FY 2011 Performance Improvement Plan: NASA is committed to continuing the efforts to remove barriers to a diverse and inclusive workplace, conducive to employees reaching their potential. In order to fully meet the objectives of the Plan, in FY 2012, NASA will: 1) undertake a careful review of the remaining actions and their target dates, taking into account new information, such as recent Government-wide initiatives relating to EEO and diversity; and 2) revise the Plan accordingly.</td></tr>
</table>

| An Inclusive and Diverse STEM Workforce | | |
|---|---|---|
| Fiscal Year 2010 Performance Improvement | **10ED03** | |
| | **Accountable Organization: Office of Education** | |
| | Serve 8,500 under-represented and under-served students in NASA higher education programs. | **FY 2010 Yellow** |
| | ***Why Measure 10ED03 was Not Met:*** In FY 2009, 6,743 higher education students self-reported as being part of an underserved and underrepresented race or ethnicity. This represents 40.6 percent of the total number of higher education students served by NASA in FY 2009, an increase from 28 percent of all higher education students similarly reporting in FY 2008. Of all higher education students served by the Agency, 43 percent self-reported being women, an increase from 41 percent in FY 2008. These figures are well above national averages for participation of minority students according to the National Science Foundation's report, Women, Minorities, and Persons with Disabilities in Science and Engineering, released in April 2010. The reduction in the number of minority higher education students served (6,743 students rather than the goal of 8,500) also reflects an increased emphasis on institutional awards for education and research, and a corresponding decrease in individual student awards. The overall reduction in direct support to all higher education students in turn affects the total number of higher education underserved and underrepresented students reached by NASA. In FY 2007, the total number of higher education students reached was 34,493; in FY 2008, the number dropped to 24,362, in FY 2009, it dropped further to 24,168. Higher education projects are adjusting to address this trend, but there is significant lag time before results are available (e.g., new course development time, time to execute activities, grant reporting lag time). Another factor adversely influencing the number of individual student awards is the increasing cost of education. To offer individual awards that remain competitive with those of other federal programs and industry, NASA grantees must increase award amounts that meet cost increases in tuition, travel, and other expenses. In a flat or reduced budget environment, an increase in award size means that fewer direct support awards can be made. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA higher education projects are actively working to increase the participation of underrepresented and underserved students. Future efforts include plans to work more closely with community colleges and institutions that tend to serve large numbers of underserved students. The Space Grant Program, which works with affiliates in all 50 states, the District of Columbia, and Puerto Rico, has actively encouraged state consortia to better engage minority-serving institutions in their networks. The consortia are accountable for improving the participation of underserved students in their programs, determined as a percentage of their audience base. The strategy has been successful, as participation of racially and ethnically underserved and underrepresented students in the Space Grant Program has increased from 15 percent in FY 2007, to 21 percent in FY 2008, and to 29 percent in FY 2009. | |
| | ***Plan Update:*** The performance improvement plan was successful, and NASA was able to work more closely with community colleges in FY 2010. In doing so, NASA increased its overall reach to underrepresented and underserved populations. However, the number of underrepresented and underserved students reported for FY 2010 does not reflect the increases seen in previous years, due to the availability of data associated with Space Grant activities. NASA released a supplemental competition, not in the first round of competitions, to the Space Grant Consortia to assist in strengthening linkages with Minority Serving Institutions, but this data will not be available until the end of the 2011 calendar year. The competition was released in late FY 2010 due to ongoing continuing resolutions which delayed funds. As a result, the currently available FY 2010 results only reflect underrepresented and underserved participation resulting from the standard Space Grant awards. The additional Space Grant awards, are expected to yield additional underrepresented and underserved participants, but will not be available until the grant performance period has concluded and grant reporting is completed. | |

| | | |
|---|---|---|
| Fiscal Year 2011 Performance Improvement | **ED-11-1 (Performance Goal 5.1.2.1)** | |
| | **Accountable Organization: Office of Education** | |
| | Achieve 40 percent participation of underserved and underrepresented (in race and/or ethnicity) in NASA higher education projects. | **FY 2011 Yellow** |
| | ***Why Measure ED-11-1 was Not Met:*** This annual performance goal was not met. Out of the 15,947 participants in NASA higher education programs who self-reported their race and ethnicity, 35 percent, reported being a member of an underserved or underrepresented race or ethnic group. NASA's aggressive goal of 40 percent, exceeds the national averages for underserved and underrepresented participation in higher education, and was a challenge that the Agency chose to undertake. The participation in NASA's programs did meet or exceed the percentages of underrepresented minorities pursuing higher education studies in STEM fields nationwide (between 11 to 21 percent of these degrees, at the bachelor level, according to the National Science Foundation Report, Women, Minorities and Persons with Disabilities in Science and Engineering: 2011). | |
| | ***FY 2011 Performance Improvement Plan:*** The cultivation of diversity is a core value for all NASA education efforts, and NASA will challenge itself to continually improve. The performance improvement plan, that addressed the last fiscal year's performance, was successful in that NASA was able to work more closely with community colleges in FY 2010, which reflected in increases seen in FY 2011 measures. In doing so, NASA increased its overall reach to underrepresented and underserved populations, moving from one year to the next. NASA has refocused several projects within the Agency's higher education portfolio during FY 2011 in pursuit of this goal, including the announcement of two new grant opportunities targeted at minority serving institutions and community colleges, which tend to have larger populations of underserved and underrepresented students. In FY 2012, NASA will seek to improve the percentage of underrepresented and underserved students, that participate in its higher education programs by placing increased emphasis on inclusion and participation by these populations in the projects that reach the largest numbers of undergraduate and graduate students, such as the Space Grant Project. Additionally, NASA plans to take a more holistic look, across the Agency, where activities in the mission organizations, may be encouraging participation, and factor in this data for a more complete picture. | |
| Fiscal Year 2011 Performance Improvement | **ED-11-2 (Performance Goal 5.1.2.1)** | |
| | **Accountable Organization: Office of Education** | |
| | Achieve 45 percent participation of women in NASA higher education projects. | **FY 2011 Yellow** |
| | ***Why Measure ED-11-2 was Not Met:*** This annual performance goal was not met. Out of the 15,568 participants in NASA higher education programs who self-reported their gender, 39 percent, reported being female. Albeit a greater number of women currently pursue higher education studies in the United States, men pursue a higher proportion of the degrees in science and engineering fields. For example, compared with men, women earn degrees at medium to low levels in physical sciences and mathematics (between 30 to 44% of these degrees), and at low levels in computer science and engineering (between 18 to 27% of these degrees). Despite the statistics, NASA still chose to set an aggressive goal of 45 percent, and fell just short of the challenge. | |
| | ***FY 2011 Performance Improvement Plan:*** In FY 2012, NASA will seek to improve the percentage of women that participate in its higher education programs by placing increased emphasis on inclusion and participation by these populations in the projects that reach the largest numbers of undergraduate and graduate students, such as the Space Grant Project. NASA currently conducts a significant number of K-12 and informal STEM education projects that specifically target participation by pre-college girls. By stimulating interest in STEM among young females in the Agency's education pipeline, NASA expects that many of these students will remain engaged and continue to participate in NASA programs upon entering college.<br><br>Additionally, NASA plans to take a more holistic look, across the Agency, where activities in the mission organizations, may be encouraging participation, and factor in this data for a more complete picture. | |

| Fiscal Year 2010 Performance Improvement | 10ED04 | |
|---|---|---|
| | **Accountable Organization: Office of Education** | |
| | Achieve 60% employment of student participants in FY 2009 NASA higher education programs by NASA, aerospace contractors, universities, and other educational institutions. | **FY 2010 Yellow** |
| | ***Why Measure 10ED04 was Not Met:*** In FY 2010, NASA's education workforce development target was 60 percent of students from NASA's higher education programs entering into NASA-related careers. Of the 1,343 students who self-reported employment data, 625 students (or 46.5 percent) reported working for NASA, aerospace contractors, universities, or other educational institutions. One project, Motivating Undergraduates in Science and Technology (MUST) was used as a prototype for more closely mapping an Office of Education project directly to the NASA Early Career Hiring Initiative. This collaborative approach succeeded in placing 22 of 29 graduates with NASA and JPL. The overall drop in employment rate in these specific sectors, relative to previous years, may be a result of uncertainty in NASA's plans (e.g., retirement of Space Shuttle Program, future of the Constellation Program), and overall poor health of the U.S. economy in 2008/2009. However, 38.6 percent of graduates (in addition to those hired by NASA, aerospace industry and educational organizations), chose STEM-related careers. One might conclude that NASA in-depth education experiences are indicative of STEM workforce preparation. | |
| | ***FY 2010 Performance Improvement Plan:*** NASA organizations with a stake in developing the future workforce will continue to work collaboratively with each other and industry partners to identify future workforce trends and needs. New efforts in the One Stop Shopping Initiative include closer collaboration between NASA's hiring managers and mentors for higher education students. | |
| | ***Plan Update:*** The performance plan was successful. In the year following, of the graduates who participated in NASA Higher education programs and self-reported employment data, 60.3 percent reported working for NASA, aerospace contractors, universities, or other educational institutions. NASA organizations have worked collaboratively with each other, as well as industry partners, to meet their respective workforce needs. Additionally, closer collaboration between NASA's hiring managers and mentors for higher education students have yielded positive results. | |

**Additional Context**

**Performance Goal 5.1.1.3:** *Achieve and sustain an effective labor-management dialogue* is rated Green.

**Performance Measure AMO-11-5:** *Identify and address at least three significant labor-management challenges identified during the year during periodic Agency-led Labor Management Forums* is grated Green. This annual performance goal was exceeded as four Labor Management Forums were held on FY 2011. Discussions in these forums addressed usage of term appointment authority, a review of the Agency performance management process with a focus on "level 2" ratings to address concerns about discrimination, and a discussion of line management/program management communication issues.

**Performance Goal 5.1.1.6:** *Implement an Agency-wide Diversity and Inclusion Framework to develop a more demographically diverse workforce and a more inclusive work environment* is rated Green.

**Performance Measure AMO-11-8:** *Establish a baseline for diversity by developing and implementing an Agency-wide diversity-inclusion survey* is grated Green. NASA deployed its Diversity and Inclusion (D&I) Assessment Survey in early FY 2010, which was responded to by 40 percent of the workforce. The results of the survey have been completed and disseminated to the Agency's D&I leads and other stakeholders, who continue to use this data to inform the development of NASA's D&I Strategic Plans.

**Performance Goal 5.1.1.1:** *Define and build the workforce skills and competencies needed for the Agency's future directions in technology development and deep space exploration* is rated Green.

**Performance Measure AMO-11-2:** *Twenty percent or more of annual recruitments will be through the early career hiring initiatives* is rated Green. This annual performance goal was met, as 20 percent of total hires in FY 2011, are considered "early career".

# Financials

Photo, previous page: A three percent scale model of a blended wing body aircraft design is tested in NASA Langley's 12-Foot Low-Speed Tunnel. During the testing, engineers sought to clarify results from a previous test of the X-48C prototype conducted in the Langley Full Scale Tunnel. (Credit: NASA/S. Smith)

# Message from the Chief Financial Officer

November 15, 2011

NASA takes seriously its responsibility for stewardship of the resources entrusted to it and for reporting on the Agency's budget and performance outcomes. This Financials section is the culmination of our efforts to present the Agency's financial status and provide transparency and accountability to the American people. It provides a comprehensive view of the financial activities undertaken to advance NASA's exploration, space operations, science, aeronautics research, and education missions. It also represents a snapshot of the financial picture resulting from the work performed on a daily basis by NASA personnel as we operate across ten centers and multiple locations in the United States and around the world.

I am very pleased to report that NASA continues to make significant progress in financial management. The results of the Agency's fiscal year 2011 financial audit are clear evidence of that progress. The Agency received an unqualified "clean" opinion on its financial statements for the first time in nine years. Additionally, NASA reported that it is substantially compliant with the Federal Financial Management Improvement Act (FFMIA) for the second consecutive year.

While the independent auditors report no material weaknesses through their audit, two significant deficiencies, one related to liability estimates and another related to information technology controls, will continue to require NASA's attention and diligence. The Agency is committed to resolving these remaining deficiencies.

We are pleased with our progress and achievements, and we remain committed to ensuring a sound financial management environment. These significant accomplishments are the result of the coordinated, focused efforts of dedicated, hard-working professionals across NASA. I appreciate the continued support of the entire Agency, with special thanks to the Office of Inspector General, as we continue to work together in our quest for excellence in financial management.

Dr. Elizabeth Robinson
Chief Financial Officer

# Introduction to the Principal Financial Statements

## Introduction and Limitations to the Financial Statements

The principal financial statements have been prepared to report the financial position and results of operations of the National Aeronautics and Space Administration (NASA), pursuant to the requirements of 31 U.S.C. 3515 (b). The statements have been prepared from the records of NASA in accordance with Generally Accepted Accounting Principles (GAAP) and the formats prescribed by the Office of Management and Budget (OMB) in Circular No. A-136, *Financial Reporting Requirements*. The statements are in addition to financial reports prepared by NASA in accordance with OMB and U.S. Department of the Treasury (Treasury) directives to monitor and control the status and use of budgetary resources, which are prepared from the same records. The statements should be read with the understanding that they are for a component of the U.S. Government, a sovereign entity. NASA has no authority to pay liabilities not covered by budgetary resources. Liquidation of such liabilities requires enactment of an appropriation. Comparative data for 2010 is included where applicable. The financial statements, which describe the results of NASA's operations and financial position, are the responsibility of NASA's management. NASA's Principal Financial Statements include the following:

The **Consolidated Balance Sheet** provides information on assets, liabilities, and net position as of the end of the reporting period, similar to balance sheets reported in the private sector. Assets must equal the sum of liabilities and net position. The difference between assets and liabilities is a measure of NASA's net position.

The **Consolidated Statement of Net Cost** reports the components of the net costs of NASA's operations for the reporting period. The net cost of operations consists of the gross cost incurred by NASA less any exchange (i.e., earned) revenue from activities.

The **Consolidated Statement of Changes in Net Position** reports the beginning net position, the transactions that affect net position for the reporting period, and the ending net position.

The **Combined Statement of Budgetary Resources** provides information on how budgetary resources were made available and their status for the reporting period. Information in this statement is reported on the budgetary basis of accounting.

**Required Supplementary Stewardship Information** provides information on NASA's Research and Development and Other Initiatives costs.

**Required Supplementary Information** contains a Combining Statement of Budgetary Resources and information on Deferred Maintenance.

# Financial Statements, Notes, and Supplemental Information

## National Aeronautics and Space Administration
## Consolidated Balance Sheet
## As of September 30, 2011 and 2010
(In Millions of Dollars)

| | Audited 2011 | Audited 2010 |
|---|---|---|
| **Assets (Note 2):** | | |
| Intragovernmental: | | |
| Fund Balance with Treasury (Note 3) | $ 9,395 | $ 8,601 |
| Investments (Note 4) | 17 | 18 |
| Accounts Receivable (Note 5) | 89 | 69 |
| Total Intragovernmental | 9,501 | 8,688 |
| Accounts Receivable, Net (Note 5) | 1 | 2 |
| Property, Plant and Equipment, Net (Note 6) | 9,840 | 9,635 |
| Other Assets (Note 8) | — | 3 |
| **Total Assets** | **$ 19,342** | **$ 18,328** |
| **Stewardship PP&E (Note 7)** | | |
| **Liabilities (Note 9):** | | |
| Intragovernmental: | | |
| Accounts Payable | $ 99 | $ 136 |
| Other Liabilities (Note 11) | 111 | 108 |
| Total Intragovernmental | 210 | 244 |
| Accounts Payable | 1,431 | 1,326 |
| Federal Employee and Veteran Benefits | 51 | 55 |
| Environmental and Disposal Liabilities (Note 10) | 1,445 | 1,041 |
| Other Liabilities (Note 11) | 1,512 | 1,647 |
| **Total Liabilities** | **4,649** | **4,313** |
| **Commitments and Contingencies (Note 12)** | | |
| **Net Position:** | | |
| Unexpended Appropriations | 6,528 | 5,706 |
| Cumulative Results of Operations | 8,165 | 8,309 |
| **Total Net Position** | **14,693** | **14,015** |
| **Total Liabilities and Net Position** | **$ 19,342** | **$ 18,328** |

The accompanying notes are an integral part of this statement.

## National Aeronautics and Space Administration
## Consolidated Statement of Net Cost
## For the Fiscal Years Ended September 30, 2011 and 2010
(In Millions of Dollars)

| | Audited 2011 | Audited 2010 |
|---|---|---|
| **Cost by Research and Development and Other Initiatives (Note 13):** | | |
| **Aeronautics Research** | | |
| Gross Costs | $ 808 | $ 816 |
| Less: Earned Revenue | 119 | 119 |
| Net Costs | 689 | 697 |
| **Exploration Systems** | | |
| Gross Costs | $ 4,791 | $ 5,360 |
| Less: Earned Revenue | 68 | 62 |
| Net Costs | 4,723 | 5,298 |
| **Science** | | |
| Gross Costs | $ 7,030 | $ 6,697 |
| Less: Earned Revenue | 1,019 | 649 |
| Net Costs | 6,011 | 6,048 |
| **Space Operations** | | |
| Gross Costs | $ 7,253 | $ 9,694 |
| Less: Earned Revenue | 58 | 429 |
| Net Costs | 7,195 | 9,265 |
| **Net Cost of Operations** | | |
| Total Gross Costs | $ 19,882 | $ 22,567 |
| Less: Total Earned Revenue | 1,264 | 1,259 |
| **Net Cost** | **18,618** | **21,308** |

The accompanying notes are an integral part of this statement.

## National Aeronautics and Space Administration
## Consolidated Statement of Changes in Net Position
## For the Fiscal Years Ended September 30, 2011 and 2010
(In Millions of Dollars)

| | Audited 2011 | Audited 2010 |
|---|---|---|
| **Cumulative Results of Operations:** | | |
| Beginning Balances | $ 8,309 | $ 13,408 |
| Adjustments: | | |
| Changes in Accounting Principle | — | (3,019) |
| Beginning Balances, As Adjusted | 8,309 | 10,389 |
| **Budgetary Financing Sources:** | | |
| Appropriations Used | 17,590 | 19,053 |
| Nonexhange Revenue | 13 | 9 |
| **Other Financing Sources:** | | |
| Donations and Forfeitures of Property | 15 | 12 |
| Transfers In/Out Without Reimbursement | 676 | (2) |
| Imputed Financing | 193 | 164 |
| Other | (13) | (8) |
| Total Financing Sources | 18,474 | 19,228 |
| Net Cost of Operations | (18,618) | (21,308) |
| Net Change | (144) | (2,080) |
| **Cumulative Results of Operations** | **8,165** | **8,309** |
| **Unexpended Appropriations:** | | |
| Beginning Balance | 5,706 | 6,128 |
| **Budgetary Financing Sources:** | | |
| Appropriations Received | 18,485 | 18,724 |
| Other Adjustments | (73) | (93) |
| Appropriations Used | (17,590) | (19,053) |
| Total Budgetary Financing Sources | 822 | (422) |
| **Unexpended Appropriations** | **6,528** | **5,706** |
| **Net Position** | **$ 14,693** | **$ 14,015** |

The accompanying notes are an integral part of this statement.

## National Aeronautics and Space Administration
## Combined Statement of Budgetary Resources
## For the Fiscal Years Ended September 30, 2011 and 2010
## (In Millions of Dollars)

| | Audited 2011 | Audited 2010 |
|---|---|---|
| Budgetary Resources: | | |
| Unobligated Balance, Brought Forward, October 1: | $ 615 | $ 1,320 |
| Recoveries of Prior Year Unpaid Obligations | 257 | 330 |
| Budgetary Authority | | |
| Appropriation | 18,486 | 18,725 |
| Spending Authority from Offsetting Collections: | | |
| Earned | | |
| Collected | 1,964 | 1,475 |
| Change in Receivables from Federal Sources | 18 | (147) |
| Change in Unfilled Customer Orders | | |
| Advance Received | 38 | (87) |
| Without Advance from Federal Sources | 11 | (14) |
| Subtotal | 20,517 | 19,952 |
| Permanently Not Available | | |
| Cancellations of Expired and No-Year Accounts | (36) | (93) |
| Enacted Reductions | (37) | — |
| Total Budgetary Resources | $ 21,316 | $ 21,509 |
| Status of Budgetary Resources: | | |
| Obligations Incurred (Note 14): | | |
| Direct | $ 18,602 | $ 19,413 |
| Reimbursable | 2,037 | 1,481 |
| Subtotal | 20,639 | 20,894 |
| Unobligated Balance: | | |
| Apportioned | 541 | 459 |
| Unobligated Balance Not Available | 136 | 156 |
| Total Status of Budgetary Resources | $ 21,316 | $ 21,509 |

The accompanying notes are an integral part of this statement.

## National Aeronautics and Space Administration
## Combined Statement of Budgetary Resources
## For the Fiscal Years Ended September 30, 2011 and 2010
(In Millions of Dollars)

| | Audited 2011 | Audited 2010 |
|---|---|---|
| **Change in Obligated Balance:** | | |
| Obligated Balances, Net | | |
| Unpaid Obligations Brought Forward, October 1 | $ 8,779 | $ 8,516 |
| Less: Uncollected Customer Payments from Federal Sources, Brought Forward, October 1 | 822 | 983 |
| **Total Unpaid Obligated Balances, Net** | **7,957** | **7,533** |
| Obligations Incurred (Note 14) | 20,639 | 20,894 |
| Less: Gross Outlays | 19,635 | 20,301 |
| Less: Recoveries of Prior Year Unpaid Obligations, Actual | 257 | 330 |
| Change in Uncollected Customer Payments from Federal Sources | (29) | 161 |
| | $ 8,675 | $ 7,957 |
| Obligated Balance, Net, End of Period | | |
| Unpaid Obligations | $ 9,526 | $ 8,779 |
| Less: Uncollected Customer Payments from Federal Sources | 851 | 822 |
| **Total, Unpaid Obligated Balance, Net, End of Period** | **$ 8,675** | **$ 7,957** |
| **Net Outlays:** | | |
| Net Outlays: | | |
| Gross Outlays | $ 19,635 | $ 20,301 |
| Less: Offsetting Collections | 2,002 | 1,388 |
| Less: Distributed Offsetting Receipts | 16 | 8 |
| **Net Outlays** | **$ 17,617** | **$ 18,905** |

The accompanying notes are an integral part of this statement.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

### Reporting Entity

The National Aeronautics and Space Administration (NASA) is an independent Agency established by Congress on October 1, 1958 by the National Aeronautics and Space Act of 1958. NASA was incorporated from the Agency's predecessor organization, the National Advisory Committee for Aeronautics, which provided technical advice to the United States (U.S.) aviation industry and performed aeronautics research. Today, NASA serves as the fulcrum for initiatives by the United States in civil space and aviation.

NASA is organized into four Research and Development and Other Initiatives (R&D/Other) which focus on the following objectives:

- Aeronautics Research: conducting research which will significantly enhance aircraft performance, environmental compatibility, and safety, and will enhance the capacity, flexibility, and safety of the future air transportation system;
- Exploration Systems: creating new capabilities, supporting technologies and foundational research for affordable, sustainable human and robotic exploration;
- Science: exploring the Earth, Moon, Mars, and beyond; charting the best route of discovery, and reaping the benefits of Earth and space exploration for society; and
- Space Operations: providing critical enabling technologies for much of the rest of NASA through the Space Shuttle, the International Space Station, and flight support.

NASA's structure includes a Strategic Management Council, a Mission Support Council, and a Program Management Council to integrate NASA's strategic, tactical and operational decisions, and a number of other committees supporting NASA's focus and direction. The organizational structure is designed to position NASA to implement the National Space Policy.

The nine NASA Centers, NASA Headquarters, and the Jet Propulsion Laboratory carry out the activities of NASA. The Jet Propulsion Laboratory is a federally funded Research and Development center owned by NASA but managed by an independent contractor.

The accompanying financial statements of NASA include the accounts of all funds which have been established and maintained to account for the resources under the control of NASA management.

### Basis of Accounting and Presentation

These consolidated financial statements are prepared in accordance with generally accepted accounting principles (GAAP) in the United States of America and standards as promulgated by the Federal Accounting Standards Advisory Board (FASAB) and the Office of Management and Budget (OMB) Circular No. A-136, *Financial Reporting Requirements*, Revised (October 2011). FASAB is recognized by the American Institute of Certified Public Accountants (AICPA) as the official accounting standards-setting body for United States government entities. The statements present the financial position, net cost of operations, changes in net position, and budgetary resources of NASA, as required by the Chief Financial Officers Act of 1990, Public Law (P.L.) 101-576, and the Government Management Reform Act (P.L. 101-356).

The financial statements should be read with the realization they are a component of the U.S. government, a sovereign entity. One implication of this is that liabilities cannot be liquidated without legislation providing resources and legal authority to do so. The accounting structure of Federal agencies is designed to reflect both accrual and budgetary accounting transactions. Under the accrual method of accounting, revenues are recognized when earned and expenses are recognized when a liability is incurred, without regard to receipt or payment of cash. Budgetary accounting facilitates compliance with legal constraints and controls over the use of Federal funds.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (continued)

### Budgets and Budgetary Accounting

NASA follows standard Federal budgetary accounting policies and practices in accordance with OMB Circular No. A-11, *Preparation Submission and Execution of the Budget*. To accomplish the goals of NASA's R&D/other initiatives, Congress funds NASA through appropriations: Science, Aeronautics, Exploration, Space Operations, Education, Cross-NASA Support, Inspector General, and Construction and Environmental Compliance and Remediation. Reimbursements to NASA are used to fund agreements between NASA and other Federal entities or the Public.

### Research and Development (R&D), Other Initiatives and Similar Costs

NASA makes substantial R&D investments for the benefit of the United States. NASA's R&D programs include activities to extend our knowledge of Earth, its space environment, and the universe; and to invest in new aeronautics and advanced space transportation technologies supporting the development and application of technologies critical to the economic, scientific, and technical competitiveness of the United States. Following guidance outlined in the Federal Accounting Standards Advisory Board's (FASAB) Technical Release No. 7, NASA applies the Financial Accounting Standards Board's (FASB) Accounting Standards Codification (ASC) 730-10-25, *Research and Development - Recognition*, and FASB ASC 730-10-50 *Research and Development - Disclosure*, to its R&D projects.

### Use of Estimates

The preparation of financial statements requires management to make estimates and assumptions affecting the reported amounts of assets and liabilities as of the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Actual results could differ from these estimates.

NASA requires major contractors to provide an estimate of their anticipated billing prior to their sending the actual invoice. In addition, NASA requires the contractors to provide an estimate for the next month's anticipated work. When NASA receives these estimates they are compared to the contract under which the work is performed. If the estimate exceeds a specified funding line item, the program manager and the procurement official, as necessary, review the estimate prior to posting in the general ledger as an estimated liability. If the review is not completed within the timeframe for quarterly or annual reporting, NASA uses the estimates of activity through the current period to establish an estimated liability. However, in this instance NASA fully recognizes that "no agency has the authority to pay liabilities not covered by budgetary resources." Liability to the contractor is not established by receipt of these estimates, but only when accepted by NASA.

NASA applies *Statement of Federal Financial Accounting Standard* (SFFAS) No. 35 in valuing General PP&E when historical cost information is not available.

### Fund Balance with Treasury

Fund Balance with Treasury (FBWT) represents NASA's funds held on deposit with the U.S. Treasury that are available to make expenditures and pay liabilities. NASA's FBWT balance is comprised in general funds, trust funds, and other types of funds.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (continued)

### Investments in U.S. Government Securities

National Aeronautics and Space Administration investments include the following Intragovernmental non-marketable securities:

1. The Endeavor Teacher Fellowship Trust Fund (Endeavor Trust Fund) was established from public donations in tribute to the crew of the Space Shuttle Challenger. The Endeavor Trust Fund balance is invested in short-term bills. P.L. 102-195 requires the interest earned from the Endeavor Trust Fund investments be used to create the Endeavor Teacher Fellowship Program.
2. The Science, Space and Technology Education Trust Fund (Challenger Trust Fund) was established for programs to improve science and technology education. The Challenger Trust Fund balance is invested in short-term bills and long-term bonds. P.L. 100-404 requires that a quarterly payment of $250,000 is sent to the Challenger Center from interest earned on the Challenger Trust Fund investments. In order to meet the requirement of providing funds to the Challenger Center, NASA invests the bi-annual interest earned in short-term bills that mature in order to provide $250,000 at the end of every quarter. Any interest received and not needed for the quarterly payment to the Challenger Center is invested in a bond maturing on February 15, 2019.

### Accounts Receivable

The majority of NASA's receivables are for intragovernmental reimbursements of R&D costs. A small portion of NASA accounts receivable are debts to NASA by non-Federal government entities. Allowances for doubtful non-Federal accounts are based on factors such as, aging of accounts receivable, debtors' ability to pay, payment history, and other relevant factors. Also, doubtful non-Federal debts over 180 days are referred to the Treasury Department for collection or cross-servicing in accordance with the federal Debt Collection Improvement Act.

### Operating Materials and Supplies

NASA does not maintain inventory stock for resale. NASA follows the purchases method of accounting for operating materials and supplies. The purchases method provides that operating materials and supplies be expensed when purchased.

### Property, Plant and Equipment

NASA reports depreciation expense using the straight-line method, beginning with the month the asset is placed into service. Property with accumulated costs of $100,000 or more, a useful life of 2 years or more, and an alternative future use is capitalized. Capitalized costs include costs incurred by NASA to bring the property to a form and location suitable for its intended use. Under provisions of the Federal Acquisition Regulation (FAR), contractors are responsible for control and accountability for Government-owned property in their possession.

NASA has barter agreements with international entities including the European Space Agency and the National Space Agency of Japan. The intergovernmental agreements state that the parties will seek to minimize the exchange of funds in the cooperative program, including the use of barters to provide goods and services. As of September 30, 2011, NASA has received some assets from these parties in exchange for future services. The fair value is indeterminable; therefore, no value was ascribed to these transactions in accordance with FASB ASC 845-10-25 *Non-Monetary Transactions* – Recognition and ASC 845-10-50 *Non-Monetary Transactions – Disclosure*. The amounts reflected in NASA's financial reports for the ISS exclude components of the ISS owned or provided by other participants in the ISS.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (continued)

### Property, Plant and Equipment (continued)

Capitalized costs for internally developed software include the full costs (direct and indirect) incurred during the software development stage only. For purchased software, capitalized costs include amounts paid to vendors for the software and material internal costs incurred by NASA to implement and make the software ready for use through acceptance testing. When NASA purchases software as part of a package of products and services (for example: training, maintenance, data conversion, reengineering, site licenses, and rights to future upgrades and enhancements), capitalized and non-capitalized costs of the package are allocated among individual elements on the basis of a reasonable estimate of their relative fair market values. Costs not susceptible to allocation between maintenance and relatively minor enhancements are expensed. NASA capitalizes costs for internal use software when the total projected cost is $1 million or more and the expected useful life of the software is 5 years or more.

### Liabilities Covered by Budgetary Resources

Liabilities covered by budgetary resources are liabilities covered by realized budgetary resources as of the balance sheet date. Realized budgetary resources include unobligated balances of budgetary resources at the beginning of the year, new budget authority, and spending authority from offsetting collections. Examples of covered liabilities include accounts payable and salaries.

### Liabilities and Contingencies Not Covered by Budgetary Resources

Generally liabilities not covered by budgetary resources are liabilities for which congressional action is needed before budgetary resources can be provided. Liabilities not covered by budgetary resources include certain environmental matters, legal claims, pensions and other retirement benefits, workers' compensation, annual leave, and closed appropriations.

### Federal Employee and Veterans' Benefits

A liability was recorded for workers' compensation claims related to the Federal Employees' Compensation Act (FECA), administered by the U.S. Department of Labor. The FECA provides income and medical cost protection to covered Federal civilian employees injured on the job, employees who have incurred a work-related occupational disease, and beneficiaries of employees whose death is attributable to a job-related injury or occupational disease. The FECA program initially pays valid claims and subsequently seeks reimbursement from the Federal agencies employing the claimants.

The FECA liability includes the actuarial liability for estimated future costs of death benefits, workers' compensation, and medical and miscellaneous costs for approved compensation cases. This liability is reported on the Federal Employee and Veteran Benefits line on the balance sheet.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 1. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES (continued)

### Personnel Compensation and Benefits

#### *Annual Sick and Other Leave*

Annual leave is accrued as it is earned; the accrual is reduced as leave is taken. Each year, the balance in the accrued annual leave account is adjusted to reflect current pay rates. To the extent current or prior year appropriations are not available to fund annual leave earned but not taken, funding will be obtained from future financing sources. Sick leave and other types of non-vested leave are expensed as taken.

#### *Retirement Benefits*

NASA employees participate in the Civil Service Retirement System (CSRS), a defined benefit plan, or the Federal Employees Retirement System (FERS), a defined benefit and contribution plan. For CSRS employees, NASA makes contributions of 7.0 percent of gross pay. For FERS employees, NASA makes contributions of gross pay of 11.7 percent to the defined benefit plan, 1 percent to a retirement saving plan (contribution plan), and matches employee contributions up to an additional 4 percent of gross pay. For FERS employees, NASA also contributes to employer's matching share for Social Security taxes.

#### *Insurance Benefits*

Statement of Federal Financial Accounting Standards (SFFAS) No. 5, *Accounting for Liabilities of the Federal Government*, requires Government agencies to report the full cost of Federal Employee Health Benefits (FEHB), and the Federal Employees Group Life Insurance (FEGLI) Programs. NASA uses the applicable cost factors and data provided by the Office of Personnel and Management to value these liabilities.

## NOTE 2. NON-ENTITY ASSETS

The majority of NASA's assets are considered entity assets. Non-entity assets represent amounts held by NASA on behalf of the U.S. Treasury that are not available for use by NASA.

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| Total Non-Entity Assets | $ 1 | $ — |
| Total Entity Assets | 19,341 | 18,328 |
| **Total Assets** | **$ 19,342** | **$ 18,328** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 3. FUND BALANCE WITH TREASURY

Fund Balance with Treasury (FBWT) represents the aggregate amount of the NASA's funds held on deposit with the U.S. Treasury that are available to make expenditures and pay liabilities. NASA's FBWT balance is comprised in general funds, trust funds, and other types of funds. General Funds primarily consist of appropriated funds for NASA. Trust Funds include balances in the Endeavor Trust Fund; Challenger Trust Fund; and Gifts and Donations Trust Fund. Other types of funds include Working Capital Fund; General Receipt funds; and Budget Clearing and Suspense funds..

| (In Millions Of Dollars) | 2011 | 2010 |
|---|---|---|
| **Fund Balances:** | | |
| General Funds | $ 9,317 | $ 8,533 |
| Trust Funds | 3 | 3 |
| Other Fund Types | 75 | 65 |
| **Total** | **$ 9,395** | **$ 8,601** |

The Status of Fund Balance with Treasury is primarily the total fund balance as recorded in the general ledger for unobligated and obligated balances. Unobligated Balances - Available is the amount remaining in appropriation funds available for obligation in future fiscal years. Unobligated Balances - Unavailable is the amount remaining in appropriation funds used only for adjustments to previously recorded obligations. Obligated Balances - Not Yet Disbursed is the cumulative amount of obligations incurred for which outlays have not been made. Non-budgetary FBWT is comprised of amounts in other types of funds.

| (In Millions Of Dollars) | 2011 | 2010 |
|---|---|---|
| **Status of Fund Balances with Treasury:** | | |
| Unobligated Balances | | |
| Available | $ 541 | $ 459 |
| Unavailable | 136 | 156 |
| Obligated Balance not Yet Distributed | 8,675 | 7,957 |
| Non-Budgetary FBWT | 43 | 29 |
| **Total** | **$ 9,395** | **$ 8,601** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 4. INVESTMENTS

NASA's investments consist of non-marketable par value intragovernmental securities issued by Treasury's Bureau of the Public Debt. The trust fund balances are invested in Treasury securities, which are purchased at either a premium or discount, and redeemed at par value exclusively through Treasury's Federal Investment Branch. The effective-interest method was utilized to amortize premiums on bonds, and the straight-line method was utilized to amortize discounts on bills.

Interest receivable on investments was less than one-half million dollars. In addition, NASA did not have any adjustments resulting from the sale of securities prior to maturity or any change in value that is more than temporary.

**2011**

| (In Millions of Dollars) | Cost | Amoritization Method | Amoritzed (Premium) Discount | Interest Receivable | Investments, Net | Other Adjustments | Market Value Disclosure |
|---|---|---|---|---|---|---|---|
| **Intragovernmental Securities:** | | Straight-Line | | | | | |
| Non- Marketable: | | Effective-interest | | | | | |
| Par value | $19 | 0.025 - 6.602% | $ (2) | $ — | $ 17 | $ — | $ 17 |
| **Total** | **$19** | | **$ (2)** | **$ —** | **$ 17** | **$ —** | **$ 17** |

**2010**

| (In Millions of Dollars) | Cost | Amoritization Method | Amoritzed (Premium) Discount | Interest Receivable | Investments, Net | Other Adjustments | Market Value Disclosure |
|---|---|---|---|---|---|---|---|
| **Intragovernmental Securities:** | | Straight-Line | | | | | |
| Non-Marketable: | | Effective-interest | | | | | |
| Par value | $19 | 0.155 - 6.602% | $ (1) | $ — | $ 18 | $ — | $ 18 |
| **Total** | **$19** | | **$ (1)** | **$ —** | **$ 18** | **$ —** | **$ 18** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 5. ACCOUNTS RECEIVABLE, NET

The Accounts Receivable balance represents valid claims by NASA to cash or other assets of another entity. Intragovernmental Accounts Receivable represents reimbursements due from other Federal entities for goods and services provided by NASA on a reimbursable basis. Accounts Receivable Due from the Public is the total of miscellaneous debts due to NASA from employees and/or smaller reimbursements from other non-Federal entities. A periodic evaluation of public accounts receivable is performed to estimate any uncollectible amounts based on current status, financial and other relevant characteristics of debtors, and the overall relationship with the debtor. An allowance for doubtful accounts is recorded, for Accounts Receivable Due from the Public, in order to bring Accounts Receivable to its Net Realizable Value in accordance with SFFAS No. 1, *Accounting for Selected Assets and Liabilities*. No allowance for doubtful accounts is necessary for Accounts Receivables Due from other federal entities. The total allowance for doubtful accounts for FY 2011 and for FY 2010 was less than one-half million dollars.

**2011**

| (In Millions of Dollars) | Accounts Receivable | Allowance for Uncollectible Accounts | Net Amount Due |
|---|---|---|---|
| Intragovernmental | $ 89 | $ — | $ 89 |
| Public | 1 | — | 1 |
| **Total** | **$ 90** | **$ —** | **$ 90** |

**2010**

| (In Millions of Dollars) | Accounts Receivable | Allowance for Uncollectible Accounts | Net Amount Due |
|---|---|---|---|
| Intragovernmental | $ 69 | $ — | $ 69 |
| Public | 2 | — | 2 |
| **Total** | **$ 71** | **$ —** | **$ 71** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 6. PROPERTY, PLANT, AND EQUIPMENT, NET (PP&E)

Property, plant and equipment is depreciated using the straight-line method, beginning with the month the asset is placed into service. Property with a unit cost of $100,000 or more and a useful life of 2 years or more and an alternative future use is capitalized. Capitalized costs include costs incurred to bring the property to a form and location suitable for its intended use. Under provisions of the Federal Acquisition Regulation (FAR), contractors are responsible for control and accountability of Government-owned property in their possession.

NASA began depreciating the International Space Station in Fiscal Year (FY) 2001 when manned by the first permanent crew. Only the Station's major elements in space, which represents U.S. owned hardware components that are delivered and installed on-orbit, are depreciated; any on-ground elements are reported as Assets Under Construction (AUC) until launched and incorporated into the existing Station structure.

NASA applies *Statement of Federal Financial Accounting Standard* (SFFAS) No. 35 in valuing General PP&E when historical cost information is not available. There is no known restriction to the use or convertibility of NASA PP&E.

In 2011, NASA determined that expenditures aggregated over several years for certain satellites under construction, which were previously reported as research and development expenditures, should be accounted for as capitalized assets. NASA evaluated the effect of this matter on each of the individual years in question and determined that the effect in any given year was not material to the financial statements. It was appropriate to make this accounting change to improve the overall accuracy of the information reported at September 30, 2011. The adjustment in 2011 had the effect of increasing Property Plant and Equipment by $699 million, decreasing Space Operation costs by $317 million and increasing Transfers In by $382 million.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 6. PROPERTY, PLANT, AND EQUIPMENT, NET (PP&E) (continued)

**2011**

| (In Millions of Dollars) | Depreciation Method | Useful Life | Cost | Accumulated Depreciation | Book Value |
|---|---|---|---|---|---|
| **Space Exploration PP&E** | | | | | |
| International Space Station | Straight-line | 5 - 20 years | $ 12,465 | $ (7,325) | $ 5,140 |
| Space Shuttle | Straight-line | 5 - 20 years | 5,516 | (5,516) | — |
| Assets Under Construction | | N/A | 1,337 | — | 1,337 |
| **Total** | | | **19,318** | **(12,841)** | **6,477** |
| | | | | | |
| **General PP&E** | | | | | |
| Land | | | 122 | — | 122 |
| Structures, Facilities and Leasehold Improvements | Straight-line | 15 - 40 years | 8,669 | (6,480) | 2,189 |
| Institutional Equipment | Straight-line | 5 - 20 years | 1,410 | (1,116) | 294 |
| Construction in Process | | N/A | 719 | — | 719 |
| Internal Use Software and Development | Straight-line | 5 years | 226 | (187) | 39 |
| **Total** | | | **11,146** | **(7,783)** | **3,363** |
| **Total Property, Plant, and Equipment** | | | **$ 30,464** | **$ (20,624)** | **$ 9,840** |

**2010**

| (In Millions of Dollars) | Depreciated Method | Useful Life | Cost | Accumulated Depreciation | Book Value |
|---|---|---|---|---|---|
| **Space Exploration PP&E** | | | | | |
| International Space Station | Straight-line | 5 - 20 years | $ 12,584 | $ (6,312) | $ 6,272 |
| Space Shuttle | Straight-line | 5 - 20 years | 8,468 | (8,468) | — |
| Assets Under Construction | | N/A | 316 | — | 316 |
| **Total** | | | **21,368** | **(14,780)** | **6,588** |
| | | | | | |
| **General PP&E** | | | | | |
| Land | | | 123 | — | 123 |
| Structures, Facilities and Leasehold Improvements | Straight-line | 15 - 40 years | 8,044 | (6,165) | 1,879 |
| Institutional Equipment | Straight-line | 5 - 20 years | 1,312 | (1,040) | 272 |
| Construction in Process | | N/A | 715 | — | 715 |
| Internal Use Software and Development | Straight-line | 5 years | 223 | (165) | 58 |
| **Total** | | | **10,417** | **(7,370)** | **3,047** |
| **Total Property, Plant, and Equipment** | | | **$ 31,785** | **$ (22,150)** | **$ 9,635** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 7. STEWARDSHIP PP&E

Federal agencies are required to classify and report heritage assets in accordance with SFFAS No. 29, *Heritage Assets and Stewardship Land*.

Stewardship PP&E have physical characteristics similar to those of general PP&E (G-PP&E) but differ from G-PP&E because their value is more intrinsic and not easily determinable in dollars. The only type of stewardship PP&E owned by NASA are Heritage Assets.

Heritage Assets are G-PP&E which possess one or more of the following characteristics:

- Historical or natural significance;
- Cultural, educational, or aesthetic value, or
- Significant architectural characteristics.

Dollar value and useful life of heritage assets are not easily determinable. There is no minimum dollar threshold for designating a G-PP&E as heritage asset, and depreciation expense is not taken on these assets. For these reasons, heritage assets are reported in physical units, rather than with assigned dollar values. In accordance with SFFAS No. 29, the cost of acquisition, improvement, reconstruction, or renovation of heritage assets is expensed in the period incurred.

Heritage assets that are used in day-to-day government operations are considered "multi-use" heritage assets that are not used for heritage purposes. Such assets are accounted for as G-PP&E and are capitalized and depreciated in the same manner as other G-PP&E. As of September 30, 2011, NASA had 112 buildings, structures, and equipment that are considered to be multi-use heritage assets. The values of these assets are included in the G-PP&E values shown in the Financial Statements.

When a G-PP&E is designated as heritage asset, its cost and accumulated depreciation are removed from the books. They remain on the record as heritage assets, except where there is legal authority for transfer or sale. However, they are withdrawn when they become inactive or reclassified as multi-use heritage assets. Heritage assets are generally in fair condition suitable for display.

NASA currently has three major classes of heritage assets: Buildings and Structures; Air and Space Displays and Artifacts; and, Art and Miscellaneous Items. The first two categories of heritage assets support NASA's mission by providing the public with tangible examples of assets which were built and deployed to support NASA's mission. Typically the Buildings and Structures have been designated as National Historic Landmarks. These real life assets enhance the public's understanding of NASA's numerous programs.

The third category of heritage assets, Art and Miscellaneous Items is mainly comprised of items created by artists who have generously contributed their time and talent to record their impressions of the U.S. Aerospace Program in paintings, drawings, and other media. These works of art not only provide a historic record of NASA projects, but they support NASA's mission by giving the public a new and fuller understanding of advancements in aerospace. Artists give a special view of NASA through the back door. Some have witnessed astronauts in training or scientists at work. The art collection, as a whole, depicts a wide range of subjects, from Space Shuttle launches to aeronautics research, Hubble Space Telescope, and even virtual reality.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 7. STEWARDSHIP PP&E (continued)

The following table depicts NASA's heritage assets inventory:

| | 2010 | Additions | Withdrawals | 2011 |
|---|---|---|---|---|
| Buildings and Structures | 16 | 3 | 6 | 13 |
| Air and Space Displays and Artifacts | 525 | 8 | 52 | 481 |
| Art and Miscellaneous Items | 1,019 | 1 | 15 | 1,005 |
| **Total Heritage Assets** | **1,560** | **12** | **73** | **1,499** |

| | 2009 | Additions | Withdrawals | 2010 |
|---|---|---|---|---|
| Buildings and Structures | 12 | 5 | 1 | 16 |
| Air and Space Displays and Artifacts | 523 | 20 | 18 | 525 |
| Art and Miscellaneous Items | 1,014 | 6 | 1 | 1,019 |
| **Total Heritage Assets** | **1,549** | **31** | **20** | **1,560** |

## NOTE 8. OTHER ASSETS

The Other Assets balance represents general PP&E assets that NASA determines are no longer needed and are awaiting disposal, retirement, or removal from services. These amounts are recorded at estimated net realizable value.

| **(In Millions of Dollars)** | **2011** | **2010** |
|---|---|---|
| Pending Disposal | $ — | $ 3 |
| **Total** | **$ —** | **$ 3** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 9. LIABILITIES NOT COVERED BY BUDGETARY RESOURCES

Liabilities not covered by budgetary resources are liabilities for which congressional action is needed before budgetary resources can be provided. They include certain environmental matters (See Note 10, Environmental and Disposal Liabilities for more information), annual leave, workers' compensation under the Federal Employees' Compensation Act (FECA) administered by the Department of Labor, closed appropriations, legal claims and pensions and other retirement benefits.

The present value of the FECA actuarial liability estimates at year-end was calculated by the Department of Labor using a discount rate of 4.03% in FY 2011 and 3.54% in FY 2010. This liability includes the estimated future costs for claims incurred but not reported or approved as of the end of each year. NASA has recorded Accounts Payable related to closed appropriations for which there are contractual commitments to pay. These payables will be funded from appropriations available for obligation at the time a bill is processed, in accordance with P.L. 101-510, National Defense Authorization Act.

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| **Intragovernment Liabilities:** | | |
| Other Liabilities | | |
| Workers' Compensation | $ 13 | $ 13 |
| Accounts Payable for Closed Appropriations | 4 | 3 |
| Total Intragovernmental | 17 | 16 |
| | | |
| **Public Liabilities:** | | |
| Accounts Payable | | |
| Accounts Payable for Closed Appropriations | 38 | 35 |
| Federal Employee and Veterans Benefits | | |
| Actuarial FECA Liability | 51 | 55 |
| Environmental and Disposal Liabilities | 1,445 | 1,041 |
| Less: Environmental and Disposal Liabilities- Funded | (226) | |
| Other Liabilities | | |
| Unfunded Annual Leave | 215 | 213 |
| **Total Liabilities Not Covered by Budgetary Resources** | **1,540** | **1,360** |
| **Total Liabilities Covered by Budgetary Resources** | **3,109** | **2,953** |
| | | |
| **Total Liabilities** | **$ 4,649** | **$ 4,313** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 10. ENVIRONMENTAL AND DISPOSAL LIABILITIES

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| Environmental Liabilities | $ 1,445 | $ 1,041 |
| **Total Environmental Cleanup** | **$ 1,445** | **$ 1,041** |

Environmental and Disposal Liabilities represents cleanup costs resulting from:

- Operations that include facilities obtained from other governmental entities that have resulted in contamination from waste disposal methods, leaks and spills;
- Other past activity that created a public health or environmental risk, or
- Total cleanup costs associated with the removal, containment, and/or disposal of hazardous wastes or material and/or property that have been deferred until operation of associated property, plant, and equipment (PP&E) ceases either permanently or temporarily.

Federal, State, and local statutes and regulations require environmental cleanup. Some of these statutes include: the Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; the Nuclear Waste Policy Act of 1982; as well as State and local laws.

NASA assesses the likelihood of required cleanup as probable, reasonably possible or remote. If the likelihood of required cleanup is probable and the cost can be reasonably estimated, a liability is recorded in the financial statements. If the likelihood of required cleanup is reasonably possible, the estimated cost of cleanup is disclosed in the notes to the financial statements. If the likelihood of required cleanup is remote, no liability is recorded or estimate disclosed.

If site-specific engineering estimates for cleanup are not available, NASA employs parametric modeling software to estimate the total cost of cleaning up known contamination at these sites for current and future years. The estimates calculated by the parametric models may be classified as probable or reasonably possible.

Consistent with SFFAS No. 6, *Accounting for Property, Plant, and Equipment*, NASA estimates the anticipated environmental disposal cleanup costs for current and planned capital PP&E. NASA recognizes and records in its financial statements an environmental cleanup liability for those in-service PP&E with a probable and measurable environmental cleanup liability of $100,000 or more.

### Probable Environmental and Disposal Liabilities

In FY 2011, NASA recorded an additional $404 million dollars of environmental and disposal liabilities to reflect the estimated total cost of environmental cleanup on known hazardous conditions bringing the total to $1,445 million, which includes anticipated cleanup at disposal for Space Shuttle and PP&E. The amount recorded in FY 2010 was $1,041 million. The majority of the increase is due to changes in individual project estimates and additional liabilities from disposal-related cleanup costs for PP&E.

## NOTE 10. ENVIRONMENTAL AND DISPOSAL LIABILITIES (continued)

The estimate for unfunded environmental liabilities could change in the future due to identification of additional contamination, inflation, deflation, a change in technology or applicable laws and regulations as well as through ordinary liquidation of these liabilities as the cleanup program continues into the future. Estimates change primarily due to updated information being available on the extent of contamination and remediation efforts that would be required.

### Reasonably Possible Environmental and Disposal Liabilities

In addition to the probable cleanup costs for known hazardous conditions recognized in the financial statements, there are other potential remediation sites where the likelihood of required cleanup for known hazardous conditions is reasonably possible. FY 2011 remediation costs at certain sites classified as reasonably possible were estimated to be $1 million dollars. In FY 2010, these remediation costs were estimated to be $116 million.

The costs necessary to cleanup Space Shuttle equipment for museum display are expected to be the responsibility of the institution displaying the equipment. If NASA is required to incur those costs, NASA estimated $46 million of Space Shuttle disposal costs in FY 2010 and $28.8 million in FY 2011 (for the periods from FY 2013 through FY 2016) as reasonably possible. Consistent with NASA's approach described above, this reasonably possible estimate is not recorded but is disclosed in the financial statements.

With respect to environmental remediation that NASA believes is reasonably possible but not estimable, NASA believes that either the likelihood of NASA liability is less than probable but more than remote or the regulatory drivers and/or technical data that exist are not reliable enough to calculate an estimate.

### Other Information

The currently proposed decommissioning approach is to execute a controlled, targeted deorbit of the International Space Station (ISS) to a remote ocean location. This is consistent with the approach used to deorbit other space vehicles such as Russian's Progress, Europe's Automated Transfer Vehicle (ATV) and Japan's H-II Transfer Vehicle (HTV). The target reliability for this decommissioning approach is calculated at 99 percent. Based on past experience with the re-entry of satellites, larger portions or fragments of the ISS would be expected to survive the thermal and aerodynamic stresses of re-entry. The debris footprint associated with the deorbit of the ISS would be targeted for remote ocean regions. The disposal of satellites and vehicles into broad ocean areas with a controlled deorbit has left little evidence of their re-entry. Any hazardous materials on board the ISS would be removed or jettisoned prior to the decommissioning. As a result, only residual quantities, if any, of hazardous, toxic, and radioactive materials would remain prior to the decommissioning. These would be expected to vaporize during the re-entry. Any remaining contamination in the ISS debris field would not be expected to have a substantive impact on marine life. Therefore, the probability of NASA incurring environmental cleanup costs related to the ISS is remote and, in accordance with SFFAS 5 & 6, no estimate for such costs has been developed or reported in these financial statements.

NASA maintains numerous structures and facilities, some of which are known to contain asbestos. Current accounting pronouncements do not require the recording of a contingent liability resulting from future asbestos remediation efforts. NASA is in the process of developing an estimate consistent with FASAB guidance.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 11. OTHER LIABILITIES

Other Liabilities are comprised of intragovernmental liabilities with other federal entities and liabilities with public entities. Other Accrued Liabilities primarily consist of the accrual of contractor costs for goods and services. The period of performance for contractor contracts typically spans the duration of NASA programs, which could be numerous years prior to final delivery of the product. In such cases, NASA records a cost accrual throughout the fiscal year as the work is performed. Other Liabilities also includes federal employee payroll and benefit liabilities, including unfunded annual leave and funded sick leave that has been earned but not taken, and salaries and wages that have been earned but are unpaid.

**2011**

| (In Millions of Dollars) | Current | Non Current | Total |
|---|---|---|---|
| **Intragovernmental Liabilities:** | | | |
| Advances From Others | $ 80 | $ — | $ 80 |
| Workers' Compensation | 6 | 7 | 13 |
| Employer Contributions and Payroll Taxes | 7 | — | 7 |
| Liability for Deposit and Clearing Funds | 6 | — | 6 |
| Liability for Non-Entity Assets Not Reported on the Statement of Custodial Activity | 1 | — | 1 |
| Other Accrued Liability | 4 | — | 4 |
| **Total Intragovernmental** | **104** | **7** | **111** |
| Unfunded Annual Leave | — | 215 | 215 |
| Accrued Funded Payroll | 44 | — | 44 |
| Advances from Others | 33 | — | 33 |
| Employer Contributions and Payroll Taxes | 4 | — | 4 |
| Liability for Deposit and Clearing Funds | 37 | — | 37 |
| Other Accrued Liabilities | 1,179 | — | 1,179 |
| **Total from the Public** | **1,297** | **215** | **1,512** |
| **Total Other Liabilities** | **$ 1,401** | **$ 222** | **$ 1,623** |

**2010**

| (In Millions of Dollars) | Current | Non-Current | Total |
|---|---|---|---|
| **Intragovernmental Liabilities:** | | | |
| Advances From Others | $ 64 | $ — | $ 64 |
| Workers' Compensation | 5 | 8 | 13 |
| Employer Contributions and Payroll Taxes | 25 | — | 25 |
| Liability for Deposit and Clearing Funds | — | — | — |
| Liability for Non-Entity Assets Not Reported on the Statement of Custodial Activity | — | — | — |
| Other Accrued Liability | 6 | — | 6 |
| **Total Intragovernmental** | **100** | **8** | **108** |
| Unfunded Annual Leave | — | 213 | 213 |
| Accrued Funded Payroll | 115 | — | 115 |
| Advances from Others | 35 | — | 35 |
| Employer Contributions and Payroll Taxes | 4 | — | 4 |
| Liability for Deposit and Clearing Funds | 28 | — | 28 |
| Other Accrued Liabilities | 1,252 | — | 1,252 |
| **Total from the Public** | **1,434** | **213** | **1,647** |
| **Total Other Liabilities** | **$ 1,534** | **$ 221** | **$ 1,755** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 12. CONTINGENT LIABILITIES

NASA is a party in various administrative proceedings, court actions (including tort suits), and claims. For cases management and legal counsel believe it is probable that the outcomes will result in a loss to NASA, liabilities are recorded. For September 30, 2011 and September 30, 2010, the amount of liability recorded was less than $1 million. There were certain cases reviewed by legal counsel where the probable future loss is remote and as such no liability has been recorded in connection with these cases.

NASA is concluding the Constellation and Space Shuttle programs; as a result, certain contracts in support of these programs are nearing completion. It is possible that additional liabilities and costs may result, including those to cover employee benefit plans. In addition, certain other contracts may contain provisions regarding contingency obligations to fund accumulated unfunded employee benefit plans upon contract termination.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 13. INTRAGOVERNMENTAL COST AND EXCHANGE REVENUE

Intragovernmental costs and revenue are exchange transactions made between NASA and other federal government entities. Costs and revenue with the Public result from transactions between NASA and other non-federal entities.

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| **Aeronautics Research** | | |
| Intragovernmental Costs | $ 60 | $ 46 |
| Public Cost | 748 | 770 |
| Total Aeronautics Research Costs | 808 | 816 |
| Less: | | |
| Intragovernmental Earned Revenue | 101 | 103 |
| Public Earned Revenue | 18 | 16 |
| Total Aeronautics Research Earned Revenue | 119 | 119 |
| **Total Aeronautics Research Net Cost** | **$ 689** | **$ 697** |
| **Exploration Systems** | | |
| Intragovernmental Costs | $ 228 | $ 250 |
| Public Cost | 4,563 | 5,110 |
| Total Exploration Systems Costs | 4,791 | 5,360 |
| Less: | | |
| Intragovernmental Earned Revenue | 48 | 45 |
| Public Earned Revenue | 20 | 17 |
| Total Exploration Systems Earned Revenue | 68 | 62 |
| **Total Exploration Systems Net Cost** | **$ 4,723** | **$ 5,298** |
| **Science** | | |
| Intragovernmental Costs | $ 400 | $ 411 |
| Public Cost | 6,630 | 6,286 |
| Total Science Costs | 7,030 | 6,697 |
| Less: | | |
| Intragovernmental Earned Revenue | 985 | 623 |
| Public Earned Revenue | 34 | 26 |
| Total Science Earned Revenue | 1,019 | 649 |
| **Total Science Net Cost** | **$ 6,011** | **$ 6,048** |
| **Space Operations** | | |
| Intragovernmental Costs | $ 401 | $ 404 |
| Public Cost | 6,852 | 9,290 |
| Total Space Operations Costs | 7,253 | 9,694 |
| Less: | | |
| Intragovernmental Earned Revenue | (20) | 369 |
| Public Earned Revenue | 78 | 60 |
| Total Space Operations Earned Revenue | 58 | 429 |
| **Total Space Operations Earned Net Cost** | **$ 7,195** | **$ 9,265** |
| **Net Cost of Operations** | **$ 18,618** | **$ 21,308** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2011 (audited)

## NOTE 14. APPORTIONMENT CATEGORIES OF OBLIGATIONS INCURRED: DIRECT VS. REIMBURSABLE OBLIGATIONS

Category A consists of amounts requested to be apportioned for each calendar quarter in the fiscal year. Category B consists of amounts requested to be apportioned on a basis other than calendar quarters, such as time periods other than quarters, activities, projects, objects, or a combination thereof.

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| **Direct Obligations:** | | |
| Category A | $ 1 | $ 1 |
| Category B | 18,601 | 19,412 |
| **Reimbursable Obligations:** | | |
| Category B | 2,037 | 1,481 |
| **Total Obligations Incurred** | **$ 20,639** | **$ 20,894** |

## NOTE 15. EXPLANATION OF DIFFERENCES BETWEEN THE STATEMENT OF BUDGETARY RESOURCES (SBR) AND THE BUDGET OF THE U.S. GOVERNMENT

The FY 2013 *Budget of the United States Government* (President's Budget) presenting the actual amounts for the year ended September 30, 2011 has not been published as of the issue date of these financial statements. The FY 2013 President's Budget is scheduled for publication in 2012.

NASA reconciled the amounts of the FY 2010 column on the Statement of Budgetary Resources (SBR) to the actual amounts for FY 2010 in the FY 2012 President's Budget for budgetary resources, obligations incurred, distributed offsetting receipts and net outlays as presented below.

| (In Millions of Dollars) | Budgetary Resources | Obligations | Distributed Offsetting Receipts | Net Outlays |
|---|---|---|---|---|
| **Combined Statement of Budgetary Resources** | $ 21,509 | $ 20,894 | $ 8 | $ 18,905 |
| Included on SBR, not in the President's Budget | | | | |
| Expired Accounts | (154) | (15) | — | — |
| Distributed Offsetting Receipts | — | -- | (8) | 8 |
| Other | 3 | — | — | — |
| **Budget of the United States Government** | **$ 21,358** | **$ 20,879** | **$ —** | **$ 18,913** |

The difference between the SBR and the President's Budget represents expired, distributed offsetting receipts reported on the SBR but not in the President's Budget and other is primarily rounding.

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 16. UNDELIVERED ORDERS AT THE END OF THE PERIOD

Undelivered Orders at the end of the period totaled $6.8 billion and $5.9 billion as of September 30, 2011 and September 30, 2010, respectively.

## NOTE 17. RECONCILIATION OF NET COST TO BUDGET

SFFAS No.7, *Accounting for Revenues and Other Financing Concepts for Reconciling Budgetary and Financial Accounting*, requires a reconciliation of proprietary and budgetary accounting information. Accrual-based measures used in the Statement of Net Cost differ from the obligation-based measures used in the Statement of Budgetary Resources.

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| **Resources Used to Finance Activities** | | |
| Budgetary Resources Obligated | | |
| Obligation Incurred | $ 20,639 | $ 20,894 |
| Less: Spending Authority from Offsetting Collections and Recoveries | 2,288 | 1,557 |
| Obligations Net of Offsetting Collections and Recoveries | 18,351 | 19,337 |
| Less: Offsetting Receipts | 4 | — |
| Net Obligations | 18,347 | 19,337 |
| Other Resources | | |
| Donations & Forfeitures of Property | 15 | 12 |
| Transfers In/Out Without Reimbursements | 676 | (2) |
| Imputed Financing from Costs Absorbed by Others | 193 | 164 |
| Net Other Resources Used to Finance Activities | 884 | 174 |
| **Total Resources Used to Finance Activities** | **19,231** | **19,511** |
| **Resources Used to Finance Items Not Part of the Net Cost of Operations** | | |
| Change in Budgetary Resources Obligated for Goods, Services, and Benefits Ordered But Not Yet Provided | (823) | (245) |
| Resources that Fund Expenses Recognized in Prior Periods | (4) | (29) |
| Budgetary Offsetting Collections and Receipts that Do Not Affect the Net Costs of Operations—Other | 5 | — |
| Resources that Finance the Acquisition of Assets | (2,317) | (2,172) |
| Other Resources or Adjustments to Net Obligated Resources that Do Not Affect Net Cost of Operations | (690) | (10) |
| **Total Resources Used to Finance Items Not Part of the Net Cost of Operations** | **(3,829)** | **(2,456)** |
| **Total Resources Used to Finance the Net Cost of Operations** | **$ 15,402** | **$ 17,055** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 17. RECONCILIATION OF NET COST TO BUDGET (continued)

| (In Millions of Dollars) | 2011 | 2010 |
|---|---|---|
| **Components of Net Cost that Will Not Require or Generate Resources in the Current Period** | | |
| Components Requiring or Generating Resources in Future Periods | | |
| Increases in Annual Leave Liability | $ 2 | $ 5 |
| Increases in Environmental and Disposal Liability | 404 | 119 |
| Other | 4 | 10 |
| Total Components of Net Cost that Will Require or Generate Resources in Future Periods | 410 | 134 |
| Components Not Requiring or Generating Resources | | |
| Depreciation | 715 | 1,444 |
| Revaluation of Assets or Liabilities | (1) | 10 |
| Other | 2,092 | 2,665 |
| Total Components of Net Cost of Operations that Will Not Require or Generate Resources | 2,806 | 4,119 |
| **Total Components of Net Cost of Operations that Will Not Require or Generate Resources in the Current Period** | **3,216** | **4,253** |
| **Net Cost of Operations** | **$ 18,618** | **$ 21,308** |

**National Aeronautics and Space Administration**
Notes to Financial Statements
For the Fiscal Years 2011 (audited) and 2010 (audited)

## NOTE 18. OTHER INFORMATION

NASA does not maintain inventory stock for resale. NASA follows the purchases method of accounting for operating materials and supplies. The consumption method is not cost beneficial and does not provide the best presentation of NASA's R&D operations. The purchases method provides that operating materials and supplies be expensed when purchased. Prior to FY 2010, amounts displayed as operating materials and supplies were accounted for under the consumption method. In FY 2010, NASA adopted a change in accounting principle and implemented the purchases method of accounting. SFFAS No. 21, Reporting Corrections of Errors and Changes in Accounting Principles, states that the cumulative effect of the change on prior periods should be reported as a change in accounting principle. Accordingly, NASA adjusted the beginning balance of the cumulative results of operations in the Statement of Changes in Net Position by $3,019 million.

**National Aeronautics and Space Administration**
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

NASA's programs and activities are carried out through four R&D/Other initiatives: Aeronautics Research, Exploration Systems, Science and Space Operations. Each R&D/Other initiative costs are presented by the applicable NASA themes, which are described in the note. To provide a complete analysis of NASA cost, both R&D and non-R&D costs are presented. Non R&D costs are associated with NASA activities such as Education and Outreach, Space Operations Programs. Descriptions for the work associated with these costs are also presented.

The FY 2011 RSSI has been revised to provide a Basic, Applied and Development breakout of the Agency's research and development costs. In order to provide the additional levels of detail, NASA enhanced its evaluation process. In prior fiscal years NASA evaluated its costs at the Initiative level to determine R&D versus non-R&D cost. For FY 2011, the Agency re-evaluated its costs at the project level which resulted in a reclassification to the previously published RSSI subtotals. It was appropriate to revise the RSSI to improve the overall accuracy of the information reported at September 30, 2011. As a result of this enhanced process, some costs previously classified as R&D have been reclassified as non-R&D. The total costs incurred did not change.

## National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

### Research and Development and Other Initiative Costs by Theme

| (In Millions of Dollars) | 2011 | 2010 | 2009 | 2008 | 2007 |
|---|---|---|---|---|---|
| **Research and Development Costs** | | | | | |
| **Basic** | | | | | |
| **Aeronautics:** | | | | | |
| Aeronautics Indirect Cost* | $ 1 | $ 1 | $ — | $ — | $ — |
| **Subtotal** | $ 1 | $ 1 | $ — | $ — | $ — |
| **Exploration Systems:** | | | | | |
| Human Exploration Capacity | $ — | $ — | $ — | $ — | $ 35 |
| Exploration Research and Development | — | — | 18 | 29 | — |
| Exploration Indirect Cost* | 5 | 5 | 1 | 1 | 1 |
| **Subtotal** | $ 5 | $ 5 | $ 19 | $ 30 | $ 36 |
| **Science** | | | | | |
| Earth Science | $ 304 | $ 306 | $ 325 | $ 294 | $ 258 |
| Planetary Science | 264 | 257 | 266 | 238 | 201 |
| Astrophysics | 198 | 194 | 149 | 103 | 90 |
| Heliophysics | 85 | 85 | 62 | 51 | 39 |
| Science Indirect Cost* | 7 | 7 | 17 | 46 | 49 |
| **Subtotal** | $ 858 | $ 849 | $ 819 | $ 732 | $ 637 |
| **Space Operations** | | | | | |
| International Space Station | $ 258 | $ 363 | $ — | $ — | $ — |
| Space and Flight Support | 1 | — | — | — | — |
| Space Operation Indirect Cost* | 8 | 9 | 3 | 2 | 2 |
| **Subtotal** | $ 267 | $ 372 | $ 3 | $ 2 | $ 2 |
| **Total Basic Expenses** | **$ 1,131** | **$ 1,227** | **$ 841** | **$ 764** | **$ 675** |

## National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

### Research and Development and Other Initiative Costs by Theme (continued)

| (In Millions of Dollars) | 2011 | 2010 | 2009 | 2008 | 2007 |
|---|---|---|---|---|---|
| **Applied** | | | | | |
| **Aeronautics:** | | | | | |
| Aeronautics Research | $ 429 | $ 464 | $ 465 | $ 472 | $ 376 |
| Aeronautics Indirect Cost* | 4 | 3 | 3 | 3 | 5 |
| **Subtotal** | $ 433 | $ 467 | $ 468 | $ 475 | $ 381 |
| **Exploration Systems** | | | | | |
| Exploration Research and Development | $ 124 | $ 152 | $ 169 | $ 159 | $ 107 |
| Exploration Indirect Cost* | 28 | 26 | 21 | 17 | 17 |
| **Subtotal** | $ 152 | $ 178 | $ 190 | $ 176 | $ 124 |
| **Science** | | | | | |
| Earth Science | $ 38 | $ 41 | $ 40 | $ 39 | $ 23 |
| Science Indirect Cost* | 36 | 31 | 26 | 24 | 26 |
| **Subtotal** | $ 74 | $ 72 | $ 66 | $ 63 | $ 49 |
| **Space Operations** | | | | | |
| International Space Station | $ 1,260 | $ 1,773 | $ — | $ — | $ — |
| Space and Flight Support | 5 | — | — | — | — |
| Space Operation Indirect Cost* | 40 | 42 | 34 | 29 | 30 |
| **Subtotal** | $ 1,305 | $ 1,815 | $ 34 | $ 29 | $ 30 |
| **Total Applied Expenses** | **$ 1,964** | **$ 2,532** | **$ 758** | **$ 743** | **$ 584** |
| **Development** | | | | | |
| **Aeronautics:** | | | | | |
| Aeronautics Indirect Cost* | $ 1 | $ 2 | $ 1 | $ — | $ 1 |
| **Subtotal** | $ 1 | $ 2 | $ 1 | $ — | $ 1 |
| **Exploration Systems:** | | | | | |
| Human Exploration Capacity | $ 2,431 | $ 3,197 | $ 1,478 | $ 1,468 | $ 743 |
| Exploration Research and Development | 185 | 227 | 253 | 239 | 161 |
| Commercial Space Flight | — | — | 122 | — | — |
| Exploration Indirect Cost* | 11 | 11 | 5 | 5 | 4 |
| **Subtotal** | $ 2,627 | $ 3,435 | $ 1,858 | $ 1,712 | $ 908 |
| **Science** | | | | | |
| Earth Science | $ 665 | $ 536 | $ 420 | $ 307 | $ 212 |
| Planetary Science | 738 | 704 | 627 | 643 | 491 |
| Astrophysics | 406 | 480 | 552 | 72 | 61 |
| Heliophysics | 288 | 284 | 207 | 151 | 133 |
| Science Indirect Cost* | 14 | 13 | 118 | 598 | 525 |
| **Subtotal** | $ 2,111 | $ 2,017 | $ 1,924 | $ 1,771 | $ 1,422 |
| **Space Operations** | | | | | |
| Space and Flight Support | $ 4 | $ — | $ — | $ — | $ — |
| Space Operation Indirect Cost* | 16 | 18 | 8 | 7 | 8 |
| **Subtotal** | $ 20 | $ 18 | $ 8 | $ 7 | $ 8 |
| **Total Development Expenses** | **$ 4,759** | **$ 5,472** | **$ 3,791** | **$ 3,490** | **$ 2,339** |
| **Total Research and Development** | **$ 7,854** | **$ 9,231** | **$ 5,390** | **$ 4,997** | **$ 3,598** |

## National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

### Non-Research and Development and Other Initiative Costs by Theme

| (In Millions of Dollars) | 2011 | 2010 | 2009 | 2008 | 2007 |
|---|---|---|---|---|---|
| **Non-Research and Development Cost** | | | | | |
| **Aeronautics:** | | | | | |
| Aeronautics Research | $ 110 | $ 83 | $ 144 | $ 150 | $ 170 |
| Aeronautics Indirect Cost* | 263 | 263 | 215 | 154 | 148 |
| **Subtotal** | $ 373 | $ 346 | $ 359 | $ 304 | $ 318 |
| **Exploration Systems:** | | | | | |
| Human Exploration Capacity | $ 239 | $ 184 | $ 1,672 | $ 1,624 | $ 989 |
| Exploration Research and Development | 76 | 101 | 151 | 260 | 430 |
| Commercial Space Flight | 423 | 98 | — | — | — |
| Exploration Other | — | 10 | 4 | 22 | 160 |
| Exploration Indirect Cost* | 1,269 | 1,349 | 1,259 | 987 | 570 |
| **Subtotal** | $ 2,007 | $ 1,742 | $ 3,086 | $ 2,893 | $ 2,149 |
| **Science** | | | | | |
| Earth Science | $ 543 | $ 677 | $ 800 | $ 1,083 | $ 1,073 |
| Planetary Science | 432 | 374 | 429 | 512 | 665 |
| Astrophysics | 385 | 414 | 299 | 188 | 226 |
| Heliophysics | 223 | 231 | 283 | 419 | 309 |
| Science Other | 4 | 17 | 88 | 243 | 246 |
| Science Indirect Cost* | 2,400 | 2,046 | 1,898 | 1,381 | 879 |
| **Subtotal** | $ 3,987 | $ 3,759 | $ 3,797 | $ 3,826 | $ 3,398 |
| **Space Operations** | | | | | |
| Space Shuttle | $ 1,774 | $ 3,215 | $ 3,277 | $ 3,394 | $ 3,445 |
| International Space Station | 1,805 | 786 | 2,148 | 1,582 | 1,397 |
| Space and Flight Support | 708 | 825 | 804 | 687 | 534 |
| Space Operation Indirect Cost* | 1,374 | 2,663 | 4,796 | 1,748 | 1,027 |
| **Subtotal** | $ 5,661 | $ 7,489 | $ 11,025 | $ 7,411 | $ 6,403 |
| **Total Non-Research and Development Expenses** | **$ 12,028** | **$ 13,336** | **$ 18,267** | **$ 14,434** | **$ 12,268** |
| **Total Expenses** | **$ 19,882** | **$ 22,567** | **$ 23,657** | **$ 19,431** | **$ 15,866** |

*Indirect Costs represents R&D and Non R&D costs incurred by the Agency for various activities that support the Agency's Research and Development and Other Initiatives. These activities relate to the areas of Construction and Environmental Compliance and Restoration; Education; Institutional Investments; Congressionally Directed items; Management and Operations; and the Office of Inspector General.

**National Aeronautics and Space Administration**
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

**STEWARDSHIP INVESTMENTS: Research and Development and Other Initiatives (continued)**

NASA makes substantial research and development investments for the benefit of the nation. These amounts are expensed as incurred in determining the net cost of operations.

NASA's Research and Development and Other Initiatives programs include activities to extend our knowledge of Earth, its space environment, and the universe, and to invest in new aeronautics and advanced space transportation technologies that support the development and application of technologies critical to the economic, scientific, and technical competitiveness of the United States.

NASA defines research as systematic study towards fuller scientific knowledge or understanding of the subject matter studied. Investment in Research and Development and Other Initiatives refers to those expenses incurred to support the search for new or refined knowledge and ideas, and for the application or use of such knowledge and ideas for the development of new or improved products and processes with the expectation of maintaining or increasing national economic productive capacity or yielding other future benefits.

In turn, there are two types of research: basic and applied. Basic research is directed at the fundamental aspects of phenomena and observable facts without specific application toward processes or products in mind. Applied research gaining knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. Additionally, development is defined. It is the systematic application of knowledge or understanding, directed towards the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

## Research and Development and Other Initiatives: Theme

## Descriptions

### INITIATIVE: AERONAUTICS RESEARCH

#### Theme: Aeronautics Technology (AT)

The Aeronautics Technology theme develops technologies to improve aircraft and air system safety, security and performance; reduce aircraft noise and emissions; and increase the capacity of the National Airspace System (NAS). Programs include Aviation Safety, Airspace Systems Program, Fundamental Aeronautics, Aeronautics Test Program, and Integrated Systems Research.

### INITIATIVE: EXPLORATION SYSTEMS

#### Theme: Human Exploration Capability

The Human Exploration Capability (HEC) Theme will develop the launch and space flight vehicles that will provide the initial capability for crewed exploration missions beyond Low Earth Orbit (LEO). Programs include Multi-Purpose Crew Vehicle and Space Launch System.

#### Theme: Exploration Research and Development

The Exploration Research and Development (ERD) Theme's technology development efforts can contribute toward advances in U.S. high technology products and services. Programs include Human Research Program and Exploration Technology Development.

**National Aeronautics and Space Administration**
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

### Theme: Commercial Spaceflight

The Commercial Spaceflight Theme creates incentives for commercial providers to develop and operate safe, reliable, and affordable commercial systems to transport crew and cargo to and from the ISS and LEO. This approach will provide assured access to the ISS, strengthen America's space industry, and provide a catalyst for future business ventures to capitalize on affordable access to space. Programs include Commercial Cargo and Commercial Crew.

## INITIATIVE: SCIENCE

### Theme: Earth Science

The Earth Science Theme studies this dynamic Earth system to trace effect to cause, connect variability and forcing with response, and vastly improve national capabilities to predict climate, weather, natural hazards, and conditions in the space environment. Programs include Earth Science Research, Earth Systematic Missions, Earth System Science Pathfinder, Earth Science Multi-Mission Operations, Earth Science Technology, and Applied Sciences.

### Theme: Planetary Science

The Planetary Science Theme advances scientific knowledge of the origin and history of the solar system, including the history of life and whether it evolved beyond Earth. Programs include Planetary Science Research, Lunar Quest Program, Discovery, New Frontiers, Mars Exploration, Outer Planets, and Technology.

### Theme: Astrophysics

The Astrophysics Theme seeks to understand the cycles of matter and energy that formed, evolve, and govern the universe, and how they created the unique conditions that support life. Where are we from? Are we alone? NASA searches for answers to these questions looking far away, towards the beginning of time, to see galaxies forming, and close to home, in search of planetary systems like Earth around nearby stars. Programs include Astrophysics Research, Cosmic Origins, James Webb Space Telescope, Physics of the Cosmos, Exoplanet Exploration, and Astrophysics Explorer.

### Theme: Heliophysics

The Heliophysics Theme studies the science of the Sun-Solar System Connection to: (1) understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by explorers, and (2) demonstrate technologies that can improve future operational systems. Programs include Heliophysics Research, Living with a Star, Solar Terrestrial Probes, Heliophysics Explorer, and New Millennium.

## INITIATIVE: SPACE OPERATIONS

### Theme: Space Shuttle

Thirty-eight years ago, NASA was charged with developing the world's first reusable space transportation system, a powerful vehicle with the versatility to revolutionize how people access and operate in near-Earth space. In FY 2011, the Space Shuttle retired, marking the end of its chapter in the history of space exploration. The final flights of the Space Shuttle were dedicated to completing assembly of the International Space Station (ISS), delivering and installing the Alpha Magnetic Spectrometer (AMS) to the ISS, and prepositioning equipment so that the ISS can achieve its full research potential.

**National Aeronautics and Space Administration**
Required Supplementary Stewardship Information
Fiscal Years 2011, 2010, 2009, 2008, and 2007
Stewardship Investments: Research and Development and Other Initiatives

### Theme: International Space Station

The International Space Station Theme supports the construction and operations of a research facility in low Earth orbit. The ISS provides a multi-disciplinary, cutting edge, unique research platform to pursue microgravity and engineering research and technology-development test bed applications. The ISS is a critical step in developing, testing, and validating the next generation of space technologies and operational processes needed to explore beyond low Earth orbit. In 2011, NASA completed assembly of the ISS and signed a Cooperative Agreement with the Center for the Advancement of Science in Space (CASIS) to serve as an independent, nonprofit research management organization to develop and manage the U.S. portion of the ISS to be operated as a National Laboratory. CASIS will be a single point of contact for U.S. (non-NASA) researchers and will be responsible for developing and managing a diversified research and development portfolio and maximizing the value of the ISS by stimulating its use as a National Laboratory.

### Theme: Space and Flight Support

The Space and Flight Support Theme encompasses the 21st Century Launch Complex, Space Communications and Navigation, Human Space Flight Operations, Launch Services, Rocket Propulsion Testing, and the Space Technology Program. The Space Technology Program will advance multi-purpose technology, in some cases to flight-ready status. The Space Technology Program will complement the mission-focused technology development activities in NASA's Mission Directorates, delivering solutions to NASA's needs for new technologies in support of future NASA missions in science and exploration, as well as the needs of other government agencies and the Nation's space industry. The Space Technology Program will enable new approaches to NASA's current mission set and allow NASA to pursue entirely new missions.

The Space Technology Program will advance technology that transforms the Nation's capabilities for exploring and utilizing space. The program will support a balanced portfolio that includes near-term mission-focused technology investments and longer-range transformational technology investments that deliver revolutionary capabilities to meet NASA's goals. The Space Technology Program will mature the technologies required for the Agency's future missions in science and exploration through experimentation, tests and demonstrations; while proving new innovations that have the potential to lower the cost of space activities conducted by other government agencies and the commercial sector.

# National Aeronautics and Space Administration
## Required Supplementary Stewardship Information
## Combining Schedule of Budgetary Resources
## For the Fiscal Year Ended September 30, 2011

| (In Millions of Dollars) | Space Operations | Science Mission | Exploration Mission | Aeronautics Mission | Cross-Agency Mission | Education Mission | Office of Inspector General | American Recovery and Reinvestment Act | Construction and Environmental Compliance | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Budgetary Resources** | | | | | | | | | | | |
| Unobligated Balance, Brought Forward, October 1 | $ 154 | $ 61 | $ 145 | $ 34 | $ 23 | $ 5 | $ 2 | $ 2 | $ 85 | $ 104 | $ 615 |
| Recoveries of Prior Year Obligations | 50 | 58 | 42 | 6 | 41 | 3 | — | 8 | 10 | 39 | 257 |
| Budget Authority: | | | | | | | | | | | |
| Appropriation | 5,509 | 4,945 | 3,808 | 535 | 3,111 | 146 | 36 | — | 395 | 1 | 18,486 |
| Spending Authority from Offsetting Collections | | | | | | | | | | | |
| Earned | | | | | | | | | | | |
| Collected | 13 | — | — | — | 1,804 | — | 1 | 18 | 6 | 122 | 1,964 |
| Change in Receivable from Federal Sources | (3) | — | — | — | 23 | — | — | — | — | (2) | 18 |
| Change in Unfilled Orders | | | | | | | | | | | |
| Advance Received | (1) | — | — | — | 40 | — | — | (1) | — | — | 38 |
| Without Advance from Federal Sources | (4) | — | — | — | 70 | — | — | (17) | — | (38) | 11 |
| Subtotal | **5,514** | **4,945** | **3,808** | **535** | **5,048** | **146** | **37** | **—** | **401** | **83** | **20,517** |
| Nonexpenditure Transfers, Net: | | | | | | | | | | | |
| Actual Transfers, Budget Authority | (177) | (16) | 128 | — | 26 | — | — | — | 39 | — | — |
| Actual Transfers, Unobligation Balances | 2 | — | — | — | 1 | — | — | — | — | (3) | — |
| Permanently Not Available | | | | | | | | | | | |
| Cancellations of Expired and No-year Accounts | — | — | — | — | — | — | — | — | — | (36) | (36) |
| Enacted Reductions | (11) | (10) | (7) | (1) | (7) | — | — | — | (1) | — | (37) |
| **Total Budgetary Resources** | **$ 5,532** | **$ 5,038** | **$ 4,116** | **$ 574** | **$ 5,132** | **$ 154** | **$ 39** | **$ 10** | **$ 534** | **$ 187** | **$ 21,316** |
| **Status of Budgetary Resources** | | | | | | | | | | | |
| Obligations Incurred: | | | | | | | | | | | |
| Direct: | $ 5,399 | $ 4,955 | $ 3,927 | $ 561 | $ 3,154 | $ 126 | $ 36 | $ 8 | $ 420 | $ 16 | $ 18,602 |
| Reimbursable: | 2 | — | — | — | 1,936 | — | 1 | — | 5 | 93 | 2,037 |
| Subtotal | **5,401** | **4,995** | **3,927** | **561** | **5,090** | **126** | **37** | **8** | **425** | **109** | **20,639** |
| Unobligated Balance: | | | | | | | | | | | |
| Apportioned | 89 | 79 | 188 | 12 | 30 | 27 | — | 1 | 109 | 6 | 541 |
| Unobligated Balance Not Available | 42 | 4 | 1 | 1 | 12 | 1 | 2 | 1 | — | 72 | 136 |
| **Total Status of Budgetary Resources** | **$ 5,532** | **$ 5,038** | **$ 4,116** | **$ 574** | **$ 5,132** | **$ 154** | **$ 39** | **$ 10** | **$ 534** | **$ 187** | **$ 21,316** |

| | Space Operations | Science Mission | Exploration Mission | Aeronautics Mission | Cross-Agency Mission | Education Mission | Office of Inspector General | American Recovery and Reinvestment Act | Construction and Environmental Compliance | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Change in Obligated Balance** | | | | | | | | | | | |
| Obligated Balance, Net, October 1 | $ 1,713 | $ 2,560 | $ 1,258 | $ 207 | $ 1,042 | $ 224 | $ 6 | $ 319 | $ 302 | $ 326 | $7,957 |
| Obligations Incurred | 5,401 | 4,955 | 3,927 | 561 | 5,090 | 126 | 37 | 8 | 425 | 109 | 20,639 |
| Less: Gross Outlays | 5,058 | 4,693 | 3,431 | 502 | 4,912 | 161 | 39 | 281 | 257 | 301 | 19,635 |
| Less: Recoveries of Prior Year Unpaid Obligations | 50 | 58 | 42 | 6 | 41 | 3 | — | 8 | 10 | 39 | 257 |
| Change in Uncollected Customer Payments from Federal Sources | 7 | — | — | — | (93) | — | — | 17 | — | 40 | (29) |
| | $ 2,013 | $ 2,764 | $ 1,712 | $ 260 | $ 1,086 | $ 186 | $ 4 | $ 55 | $ 460 | $ 135 | $ 8,675 |
| Obligated Balance, Net, End of Period | | | | | | | | | | | |
| Unpaid Obligations | $ 2,018 | $ 2,764 | $ 1,712 | $ 260 | $ 1,919 | $ 186 | $ 4 | $ 56 | $ 460 | $ 147 | $ 9,526 |
| Less: Uncollected Customer Payments from Federal Sources | 5 | — | — | — | 833 | — | — | 1 | — | 12 | 851 |
| **Total, Unpaid Obligated Balance, Net, End of Period** | **$ 2,013** | **$ 2,764** | **$ 1,712** | **$ 260** | **$ 1,086** | **$ 186** | **$ 4** | **$ 55** | **$ 460** | **$ 135** | **$ 8,675** |
| **Outlays** | | | | | | | | | | | |
| Net Outlays: | | | | | | | | | | | |
| Gross Outlays | $ 5,058 | $ 4,693 | $ 3,431 | $ 502 | $ 4,912 | $ 161 | $ 39 | $ 281 | $ 257 | $ 301 | $ 19,635 |
| Less: Offsetting Collections | 12 | — | — | — | 1,844 | — | 1 | 17 | 6 | 122 | 2,002 |
| Less: Distributed Offsetting Receipts | — | — | — | — | — | — | — | — | — | 16 | 16 |
| **Net Outlays** | **$ 5,046** | **$ 4,693** | **$ 3,431** | **$ 502** | **$ 3,068** | **$ 161** | **$ 38** | **$ 264** | **$ 251** | **$ 163** | **$ 17,617** |

# National Aeronautics and Space Administration
## Required Supplementary Information
## Combining Schedule of Budgetary Resources
## For the Fiscal Year Ended September 30, 2010

| | Space Operations | Science Mission | Exploration Mission | Aeronautics Mission | Cross-Agency Mission | Education Mission | Office of Inspector General | American Recovery and Reinvestment Act | Construction and Environmental Compliance and Restoration | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Budgetary Resources** | | | | | | | | | | | |
| Unobligated Balance, Brought Forward, October 1 | $ 91 | $ 62 | $ 47 | $ 4 | $ 291 | $ 28 | $ 2 | $ 608 | $ — | $ 187 | $ 1,320 |
| Recoveries of Prior Year Obligations | 63 | 84 | 61 | 7 | 45 | — | — | 6 | — | 64 | 330 |
| Budget Authority: | | | | | | | | | | | |
| Appropriation | 6,147 | 4,469 | 3,746 | 501 | 3,194 | 183 | 36 | — | 448 | 1 | 18,725 |
| Spending Authority from Offsetting Collections | | | | | | | | | | | |
| Earned | | | | | | | | | | | |
| Collected | 8 | — | — | — | 1,226 | — | 1 | 33 | 3 | 204 | 1,475 |
| Change in Receivable Federal Sources | (1) | — | — | — | (125) | — | — | (1) | — | (20) | (147) |
| Change in Unfilled Orders | | | | | | | | | | | |
| Advance Received | (7) | — | — | — | (46) | — | 1 | 1 | — | (36) | (87) |
| Without Advance from Federal Sources | (2) | — | — | — | 108 | — | — | (29) | — | (91) | (14) |
| Subtotal | **6,145** | **4,469** | **3,746** | **501** | **4,357** | **183** | **38** | **4** | **451** | **58** | **19,952** |
| Nonexpenditure Transfers, Net: | | | | | | | | | | | |
| Actual Transfers, Budget Authority | (5) | 28 | 31 | (4) | (52) | (2) | — | — | 4 | — | — |
| Actual Transfers, Unobligation Balances | 1 | — | — | — | — | — | — | — | — | (1) | — |
| Permanently Not Available | | | | | | | | | | | |
| Cancellations of Expired and No-year Accounts | — | — | — | — | — | — | (2) | — | — | (91) | (93) |
| Enacted Reductions | — | — | — | — | — | — | — | — | — | — | — |
| **Total Budgetary Resources** | **$6,295** | **$4,643** | **$3,885** | **$508** | **$4,641** | **$209** | **$38** | **$618** | **$455** | **$217** | **$21,509** |
| **Status of Budgetary Resources** | | | | | | | | | | | |
| Obligations Incurred: | | | | | | | | | | | |
| Direct: | $6,139 | $4,582 | $3,740 | $474 | $3,220 | $203 | $35 | $612 | $369 | $39 | $19,413 |
| Reimbursable: | 2 | — | — | — | 1,398 | — | 1 | 4 | 1 | 75 | 1,481 |
| Subtotal | **6,141** | **4,582** | **3,740** | **474** | **4,618** | **203** | **36** | **616** | **370** | **114** | **20,894** |
| Unobligated Balance: | | | | | | | | | | | |
| Apportioned | 98 | 61 | 145 | 34 | 21 | 6 | 2 | 2 | 77 | 13 | 459 |
| Unobligated Balance Not Available | 56 | — | — | — | 2 | — | — | — | 8 | 90 | 156 |
| **Total Status of Budgetary Resources** | **$6,295** | **$4,643** | **$3,885** | **$508** | **$4,641** | **$209** | **$38** | **$618** | **$455** | **$217** | **$21,509** |

| | Space Operations | Science Mission | Exploration Mission | Aeronautics Mission | Cross-Agency Mission | Education Mission | Office of Inspector General | American Recovery and Reinvestment Act | Construction and Environmental Compliance and Restoration | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Change in Obligated Balance** | | | | | | | | | | | |
| Obligated Balance, Net, October 1 | $ 1,433 | $ 2,243 | $ 1,108 | $ 210 | $ 880 | $ 118 | $ 6 | $ 356 | $ — | $ 1,179 | $ 7,533 |
| Obligations Incurred | 6,141 | 4,582 | 3,740 | 474 | 4,618 | 203 | 36 | 616 | 370 | 114 | 20,894 |
| Less: Gross Outlays | 5,801 | 4,181 | 3,530 | 471 | 4,428 | 96 | 35 | 677 | 68 | 1,014 | 20,301 |
| Less: Recoveries of Prior Year Unpaid Obligations | 63 | 84 | 61 | 7 | 45 | — | — | 6 | — | 64 | 330 |
| Change in Uncollected Customer Payments from Federal Sources | 3 | — | — | — | 17 | — | — | 30 | — | 111 | 161 |
| | $ 1,713 | $ 2,560 | $ 1,257 | $ 206 | $ 1,042 | $ 225 | $ 7 | $ 319 | $ 302 | $ 326 | $ 7,957 |
| Obligated Balance, Net, End of Period | | | | | | | | | | | |
| Unpaid Obligations | $ 1,725 | $ 2,560 | $ 1,257 | $ 206 | $ 1,782 | $ 225 | $ 7 | $ 337 | $ 302 | $ 378 | $ 8,779 |
| Less: Uncollected Customer Payments from Federal Sources | 12 | — | — | — | $740 | — | — | 18 | — | 52 | 822 |
| **Total, Unpaid Obligated Balance, Net, End of Period** | **$ 1,713** | **$ 2,560** | **$ 1,257** | **$ 206** | **$ 1,042** | **$ 225** | **$ 7** | **$ 319** | **$ 302** | **$ 326** | **$ 7,957** |
| **Outlays** | | | | | | | | | | | |
| Net Outlays: | | | | | | | | | | | |
| Gross Outlays | $ 5,801 | $ 4,181 | $ 3,530 | $ 471 | $ 4,428 | $ 96 | $ 35 | $ 677 | $ 68 | $ 1,014 | $ 20,301 |
| Less: Offsetting Collections | 1 | — | — | — | 1,180 | — | 2 | 34 | 3 | 168 | 1,388 |
| Less: Distributed Offsetting Receipts | — | — | — | — | — | — | — | — | — | 8 | 8 |
| **Net Outlays** | **$ 5,800** | **$ 4,181** | **$ 3,530** | **$ 471** | **$ 3,248** | **$ 96** | **$ 33** | **$ 643** | **$ 65** | **$ 838** | **$ 18,905** |

**National Aeronautics and Space Administration**
Required Supplementary Information
For the Fiscal Years 2011 and 2010

## DEFERRED MAINTENANCE

NASA uses a Deferred Maintenance parametric estimating method (DM method) in order to conduct a consistent condition assessment of its facilities, buildings, and other structures (including heritage assets). This method measures NASA's current real property asset condition and documents real property deterioration. The DM method produces both a cost estimate of deferred maintenance, and a Facility Condition Index (FCI). Both measures are indicators of the overall condition of NASA's facilities. The facilities condition assessment methodology involves an independent, rapid visual assessment of nine different systems within each facility to include: structure, roof, exterior, interior finishes, HVAC, electrical, plumbing, conveyance, and program support equipment. The DM method is designed for application to a large population of facilities; results are not necessarily applicable for individual facilities or small populations of facilities. Under this methodology, NASA defines acceptable operating conditions in accordance with standards comparable to those used in private industry, and the aerospace industry.

There has been no significant change in our deferred maintenance estimate this year. The Agency-wide FCI, based on the ratings obtained during the condition assessment site visits, remains unchanged from the previous fiscal year. The FCI values for the majority of individual Centers and sites varied less than 0.5, validating the relative stability of the Centers and sites despite the continued aging and deterioration of older facilities. Evaluation of the facility conditions by building type (Real Property Classification Code/DM Category) indicates that the Agency continues to focus maintenance and repair on direct mission-related facilities. Higher condition ratings are reported for potable water facilities, launch, communication and tracking, and fuel facilities Agency-wide. Lower condition ratings occur for infrastructure, site related systems, and static test stands.

| Deferred Maintenance Method | 2011 | 2010 |
|---|---|---|
| Facility Condition Index (FCI) | 3.7 | 3.6 |
| Target Facility Index | 3.8 | 3.8 |
| Deferred Maintenance Estimate | | |
| (Active and Inactive Dollars) | $ 2,472 | $ 2,553 |
| (In Millions of Dollars) | | |

# Letter from the Inspector General on the Audit

National Aeronautics and
Space Administration

**Office of Inspector General**
Washington, DC 20546-0001

November 15, 2011

TO: Charles F. Bolden, Jr.
Administrator

Elizabeth Robinson
Chief Financial Officer

FROM: Paul K. Martin
Inspector General

SUBJECT: Audit of the National Aeronautics and Space Administration's Fiscal Year 2011 Financial Statements (Report No. IG-12-004; Assignment No. A-11-016-00)

The Office of Inspector General contracted with the independent public accounting firm PricewaterhouseCoopers LLP (PwC) to audit NASA's financial statements in accordance with the Government Accountability Office's *Government Auditing Standards* and the Office of Management and Budget's Bulletin No. 07-04, "Audit Requirements for Federal Financial Statements," as amended.

The audit resulted in an unqualified opinion on NASA's fiscal year (FY) 2011 financial statements (Enclosure 1). An unqualified opinion means that the financial statements present fairly, in all material respects, the financial position and the results of the entity's operations in conformity with U.S. generally accepted accounting principles. The results of the FY 2011 audit were a notable improvement over FY 2010, when the Agency received a qualified opinion due to the valuation of property, plant, and equipment and materials in prior years and the possible effects to the 2010 statements of net cost and changes in net position.

PwC also issued its reports on internal control and compliance with laws and regulations (Enclosures 2 and 3, respectively). For FY 2011, PwC identified two significant deficiencies related to (1) the environmental liability estimation process and (2) privileged user access controls and monitoring of the financial management system environment. During the audit, PwC identified no instances of significant noncompliance with applicable laws and regulations.

In fulfilling our responsibilities under the Chief Financial Officers Act of 1990, we monitored the progress of the audit, reviewed PwC's reports and related documentation, inquired of PwC's representatives, and ensured that PwC met contractual requirements. Our review was not intended to enable us to express, and we do not express, an opinion

on NASA's financial statements; conclusions about the effectiveness of internal controls over financial reporting; or compliance with certain laws and regulations, including, but not limited to, the Federal Financial Management Improvement Act of 1996.

PwC is responsible for each of the enclosed reports and the conclusions expressed therein. Our review, while still ongoing, disclosed no instances where PwC did not comply in all material respects with the Government Accountability Office's *Government Auditing Standards.*

Please contact us if you have any questions about the enclosed reports.

3 Enclosures

# Report of the Independent Auditors

**Report of Independent Auditors**

To the Administrator and the Inspector General
of the National Aeronautics and Space Administration

We have audited the accompanying consolidated balance sheet of the National Aeronautics and Space Administration (NASA) as of September 30, 2011, and the related consolidated statements of net cost and changes in net position, and the combined statement of budgetary resources for the year then ended. These financial statements are the responsibility of NASA's management. Our responsibility is to express an opinion on the September 30, 2011 financial statements based on our audit. The financial statements of NASA as of and for the year ended September 30, 2010, were audited by other auditors whose report dated November 15, 2010, expressed an unqualified opinion on the consolidated balance sheet and the combined statement of budgetary resources and a qualified opinion on the consolidated statements of net costs and changes in net position due to an inability to obtain sufficient evidence supporting depreciation, property, plant and equipment and operating materials and supplies (OM&S) and contained an explanatory paragraph regarding an election by NASA to change its method of accounting for OM&S from the consumption method to the purchases method.

We conducted our audit in accordance with auditing standards generally accepted in the United States of America, the standards applicable to financial audits contained in *Government Auditing Standards*, issued by the Comptroller General of the United States, and Office of Management and Budget (OMB) Bulletin No. 07-04, *Audit Requirements for Federal Financial Statements*, as amended. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

In our opinion, the financial statements referred to above present fairly, in all material respects, the consolidated financial position of NASA at September 30, 2011, and its consolidated net cost of operations and changes in net position, and the combined budgetary resources for the year then ended, in conformity with accounting principles generally accepted in the United States of America.

The Management's Discussion and Analysis (MD&A), Required Supplementary Information (RSI), and Required Supplementary Stewardship Information (RSSI) are not a required part of the financial statements but are supplementary information required by the Federal Accounting Standards Advisory Board and OMB Circular A-136, *Financial Reporting Requirements*. We have applied certain limited procedures, which consisted principally of inquiries of management regarding the methods of measurement and presentation of the MD&A, RSI, and RSSI. However, we did not audit the information and express no opinion on it.

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Our audit was conducted for the purpose of forming an opinion on the consolidated and combined financial statements of NASA taken as a whole. The Other Accompanying Information is presented for purposes of additional analysis and is not a required part of the consolidated or combined financial statements. Such information has not been subjected to the auditing procedures applied in the audit of the consolidated and combined financial statements and, accordingly, we express no opinion on it.

In accordance with *Government Auditing Standards,* we have also issued a report dated November 15, 2011**,** on our consideration of NASA's internal control over financial reporting and a report dated November 15, 2011, on its compliance and other matters for the year ended September 30, 2011. The purpose of those reports is to describe the scope of our testing of internal control over financial reporting and compliance and the results of that testing, and not to provide an opinion on the internal control over financial reporting or on compliance. Those reports are integral part of an audit performed in accordance with *Government Auditing Standards* and should be read in conjunction with this report in considering the results of our audit.

PricewaterhouseCoopers LLP

November 15, 2011

# Report of the Independent Auditors on Internal Control

**Report of Independent Auditors on Internal Control**

To the Administrator and the Inspector General
of the National Aeronautics and Space Administration

We have audited the financial statements of the National Aeronautics and Space Administration (NASA) as of and for the year ended September 30, 2011 and have issued our report thereon dated November 15, 2011. We conducted our audit in accordance with auditing standards generally accepted in the United States of America, the standards applicable to financial audits contained in *Government Auditing Standards,* issued by the Comptroller General of the United States, and Office of Management and Budget (OMB) Bulletin No. 07-04*, Audit Requirements for Federal Financial Statements*, as amended. The management of NASA is responsible for maintaining effective internal control over financial reporting.

In planning and performing our audit, we considered the NASA's internal control over financial reporting as a basis for designing our auditing procedures for the purpose of expressing our opinion on the financial statements, but not for the purpose of expressing an opinion on the effectiveness of NASA's internal control over financial reporting. Accordingly, we do not express an opinion on the effectiveness of the NASA's internal control over financial reporting.

We limited our control testing to those controls necessary to achieve the following OMB control objectives that provide reasonable, but not absolute assurance, that: (1) transactions are properly recorded, processed, and summarized to permit the preparation of the financial statements in accordance with accounting principles generally accepted in the United States of America, and to safeguard assets against loss from unauthorized acquisition, use, or disposition; and (2) transactions are executed in compliance with laws governing the use of budget authority, government-wide policies and laws identified in Appendix E of OMB Bulletin No. 07-04, and other laws and regulations that could have a direct and material effect on the financial statements.

We did not test all internal controls relevant to the operating objectives broadly defined by the Federal Managers' Financial Integrity Act of 1982.

A deficiency in internal control exists when the design or operation of a control does not allow management or employees, in the normal course of performing their assigned functions, to prevent, or detect and correct misstatements on a timely basis.

A material weakness is a deficiency, or a combination of deficiencies, in internal control such that there is a reasonable possibility that a material misstatement of NASA's financial statements will not be prevented, or detected and corrected on a timely basis.

A significant deficiency is a deficiency or a combination of deficiencies in internal control that is less severe than a material weakness, yet important enough to merit attention by those charged

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with governance. We identified certain deficiencies in internal control over financial reporting that we consider to be significant deficiencies. These deficiencies are:

**Environmental Liability Estimation Process**

NASA has recorded a total Environmental Liability in the amount $1,445 million within its balance sheet. NASA's management has invested resources to develop policies and procedures to accurately estimate and report this liability. The results of our testing have identified that improvements related to NASA's environmental liability policies or procedures are needed. Specifically, we noted the following:

1. Environmental Liability Policies and the Application of these Policies.

   NASA calculates an environmental liability associated with the following sub-categories of projects/assets: 1) Restoration Projects, 2) Property, Plant, and Equipment (PP&E) - excluding Space Shuttle Assets, and 3) Space Shuttle Assets.

   - **Inconsistencies in the application of the restoration project environmental liability policy**: NASA's key control in determining the appropriateness of the environmental liability associated with Restoration Projects (sub-category) is the joint review process. As stipulated within the restoration project environmental liability policy, a joint review is conducted annually to validate the environmental liability estimates. During our observation of the joint review process, we noted the process did not consistently identify errors in the application of the estimation policy which lead to an underestimation of the liability, which was subsequently corrected.

   - **Lack of clarity related to the PP&E environmental liability policy and inconsistency in the application of the policy**: As it relates to the PP&E (sub-category), we noted instances where NASA has analyzed an environmental liability for specific assets included within its permitted facilities but has not provided a liability analysis for similar assets included within its non-permitted facilities. According to management, an assessment of potential clean-up costs is only required for assets held within facilities where a permit is required to operate the facility. However, there are times in which the local State, County, or City statutes, regulations and ordinances do not require operation permits, but potential clean-up liabilities could exist due to the requirements embedded in those statutes, regulations or ordinances. NASA has not estimated a liability for the non-permitted facilities.

     During our review, we also noted that Restoration Project Managers (RPMs) and environmental staff used an operational definition for environmental clean-up costs which differs from the accounting definition set by the Federal Accounting Standards Advisory Board (FASAB). In addition, we noted differing applications of the liability requirements between proprietary and budgetary accounting, such as recording liabilities net of proceeds from asset disposition.

- **Lack of space exploration assets environmental liability policy**: Although NASA has included a liability for the clean-up of the Space Shuttle Assets within the environmental liability, a formal policy related to the estimation of future clean-up cost associated with NASA's exploration assets, inclusive of the Space Shuttle Assets does not exist. The lack of a formal policy outlining the procedures that should be used by management to estimate future clean-up costs associated with NASA's exploration assets has lead to weaknesses in the process used to validate the estimate. NASA's policy does not specify the processes to follow to ensure that the liability is calculated in accordance with the applicable accounting standards and related reporting guidance. In addition, management was unable to provide evidence of their review of this portion of the overall liability estimate.

2. Analyses Supporting the Environmental Liability Estimates.

   - **Lack of analysis related to established environmental liability threshold:** NASA only records a future environmental clean-up cost liability if the clean-up cost for an asset is estimated to be above $100,000. NASA was unable to provide an analysis that would evidence that the established threshold was appropriate or supported by the accounting literature. In addition, NASA was unable to provide evidence to support their assertion that aggregation risk associated with amounts below $100,000 is acceptable based on their current asset population.

   - **Lack of analysis of potential environmental clean-up costs associated with PP&E**: NASA's policy identifies the following PP&E categories for environmental liability estimation purposes: 1) Buildings and Building Components, 2) Tanks, both above and underground, 3) Permitted Facilities (other than tanks), and 4) Fixtures and Equipment. However, NASA recognizes and records in its financial statements an environmental cleanup liability for those in-service permitted PP&E facilities (category 3) and excludes the other categories of non-permitted PP&E (categories 1, 2, and 4) with a probable and measurable environmental cleanup liability.

     NASA was unable to provide evidence to support the assertion that categories 1, 2, and 4 should be excluded from the environmental liability calculation. According to management, any potential liabilities within these excluded categories are thought to be included within the Restoration Projects liability. However NASA was unable to provide evidence to support the assertion that these liabilities would be covered as part of the Restorations Projects.

   - **Lack of analyses and/or support related to the methods and assumptions used to develop the space exploration assets environmental liability estimate**: NASA's environmental liability estimates for its space exploration programs include estimates related to future clean-up costs associated with the Space Shuttle assets and assets temporarily assigned to the Constellation Program. NASA was unable to provide supporting documentation for key assumptions or methodology used to calculate the liability associated with the Space Shuttle Program.

NASA was unable to provide evidence that the analysis supporting the Constellation Program's projected clean-up cost was complete. We also noted that the methodology used to develop the projected clean-up cost for the Constellation Program assets was different than that used for the Shuttle Program. NASA was unable to provide documentation to support the rationale for the differing methodologies.

3. Inappropriate Interpretation of Accounting Standards related to the Recording of Environmental Liabilities.

   During our review of the environmental liability estimates prepared by NASA, we noted that management was excluding the funded portion of the liability from its financial statements. This treatment is inconsistent with related accounting standards and Treasury reporting requirements. For example, NASA has received $43 million dollars in appropriated funding to perform work related to its restoration projects; however, this amount was initially excluded from the reported environmental liability. Subsequent to our testing, NASA updated the official books and records to include this amount within the liability estimate.

   We also noted that NASA's environmental liability policy encourages estimators to offset expected losses against potential gains from the salvage value of assets or other estimated recoveries. This treatment is inconsistent with authoritative accounting literature.

**Recommendations**

We recommend that NASA:

- Further enhance the process and procedures performed during the joint review process. NASA should increase the level of due diligence performed during their Joint Review Process by developing specific programs/checklists that should be followed during this monitoring process. This will ensure that the focus of each review is consistent from project to project. In addition, we recommend NASA extend its joint review process to estimates related to PP&E and Space Exploration. The enhancement of the Joint Review Process will provide NASA with additional assurance related to the reasonableness of the estimates.

- Provide additional clarity regarding its PP&E environmental liability policy and develop a comprehensive Space Exploration liability policy. The PP&E policy should be clarified to provide guidance and procedures related to the estimation process for all sub-categories of PP&E. The Space Exploration liability policy should establish procedures to ensure the liability is complete and requirements to document the rationale for differences in methods used to calculate the liability between programs (e.g., Space Shuttle Program vs. Constellation Program). The policies should be in compliance with and reference appropriate accounting standards and other applicable reporting requirements.

- Ensure that the analyses supporting the estimates derived from the implementation of the estimation policies identify the data, factors, assumptions, and methods used to develop the estimates. NASA should also retain all relevant documentation that supports the analysis and related estimates. To the extent that NASA believes that the accounting standards allow for the establishment of a liability "threshold" for individual assets, this determination should be fully analyzed and documented. The documentation of this liability "threshold" should also include an analysis of the aggregation risk associated with the related classes of assets. Finally, NASA should ensure that this analysis is updated on a regular basis to address changes, in facts and circumstances.

**Privileged User Access Controls and Monitoring of the SAP Environment**

Our audit identified privileged access weaknesses and inadequate logging and monitoring that, when aggregated, increase the risk that unauthorized, undetected modifications could be made to NASA's financial data and systems. Our testing disclosed the following:

1. Two unlocked, Dialog SAP IDs had been assigned the critical SAP_ALL profile. This access allows broad, transactional access to the production environment, including, but not limited to, the ability to post accounting documents, create users, open the production environment for direct changes, and delete logs. Additionally, one of these Dialog SAP IDs had been assigned the SAP_NEW profile, which in combination with the SAP_ALL profile, granted extensive access to users. Persons assigned these access rights had the ability to perform broad, critical functions within SAP, including functions typically segregated.

2. Twenty-eight SAP users across the NASA Enterprise Applications Competency Center (NEACC) Security Access Management, Basis, Application Technical Support, Business Warehouse, and Competency Center teams were granted the ability to execute commands against the production environment without the enforcement of SAP authorization checks.

3. In addition, the same twenty-eight SAP users had been granted various development and debugging abilities on the production environment instance of SAP. Users with this access had the ability to deactivate and bypass authorization checks and change data dictionary objects.

4. Eight members of the NEACC Security Access Management Group had access to modify system settings within SAP, which was not commensurate with their job responsibilities. This access allowed them to unlock the production environment for direct changes, performance of development activities, and changes to tables, which bypassed established configuration management procedures.

5. Service and administrative accounts on the in-scope Oracle database and Solaris servers were shared among multiple users. The use of shared accounts by System Administrators prevents the timely assessment of accountability for actions taken within the system.

6. Application logs were maintained; however, periodic reviews of user activity were not performed and documented. Administrators relied on personnel to alert them to suspected malicious activity, rather than performing a regular review. In addition, privileged user activity was not auditedwithin the supporting Oracle database.

Despite a mature Information Technology control environment, the combination of these weaknesses is significant enough to expose NASA's financial management system to multiple risks. As a result of the excessive and shared privileged access noted above, coupled with a lack of proactive, documented review of user activity, there is a risk that improper or inaccurate transactions of more than inconsequential amounts could be processed and recorded in the financial statements without timely detection.

Personnel at the NEACC have been proactive in researching these conditions, and in some instances, taking immediate corrective action. The NEACC has also responded with a longer-term remediation plan to address these weaknesses.

**Recommendations**

We recommend that NASA:

- Remove broad, privileged SAP profiles from unlocked, Dialog IDs in the production environment. Update the profiles to be commensurate with users' primary job responsibilities, as opposed to granting broad transactional access via SAP_ALL.

  A custom emergency ID should be created with the privileged abilities required by the NEACC to perform required job responsibilities which do not result in a segregation of duties violation. This ID should be locked in the production environment when not in use, and those with the ability to change the password in the system should be adequately restricted. Procedures should be created, building on controls already in place, for requesting, approving, monitoring, and retaining documentation supporting the usage of this ID.

- Perform a review of privileged roles, access abilities, and authorization objects assigned to users to confirm the assignment is necessary and commensurate with users' documented job responsibilities. Processes should be developed to manage the administration of privileged access abilities and authorization objects if they are ever needed in the production environment, as well as to monitor the usage of that access when granted in the production environment.

- Perform a review to identify all service and administrative accounts that are shared among Oracle and Solaris administrators to confirm granted access is required. Unique accounts should be created for all users in the Oracle database and Solaris operating system, with activity on those accounts regularly monitored. If the creation of unique accounts is not feasible, the NEACC should restrict the shared access to only those users who require it on a regular basis. Processes should be developed to manage the

administration of this shared access when it is needed, as well as to monitor and document the usage of the shared access.

- Ensure that application logs are actively reviewed for unauthorized or malicious activity. Although NASA has policies in place, proactive reviews of the logs should be performed to detect and respond to suspicious activity. Due to the volume of application logs, NASA should perform a risk assessment isolating specific higher-risk activity to review for, and develop and implement a procedure to actively monitor logs for this activity.

Our consideration of internal control was for the limited purpose described in the second paragraph of this report and would not necessarily identify all deficiencies in internal control over financial reporting that might be significant deficiencies or material weaknesses and therefore, there can be no assurance that all deficiencies, significant deficiencies, or material weaknesses have been identified. We did not identify any deficiencies in internal control that we consider to be material weaknesses, as defined above.

We have discussed our findings and recommendations with NASA's management. Management will provide a corrective action plan to address the findings identified in this report. We have not performed additional procedures to validate the corrective actions.

We did note other matters involving the internal control and its operation that we will communicate to NASA in a separate letter.

**Status of Prior-Year Findings**

In the report on the results of the FY 2010 audit of the NASA's financial statements, two issued were raised relating to internal control. The chart below summarizes the current status of these prior year items:

| Issue Area | Control Deficiency Categorization | FY 2011 Status |
|---|---|---|
| Enhancements Needed for Controls over Property, Plant & Equipment Records Maintained by Contractors | Significant Deficiency | Closed |
| Enhancements Needed for Recognition of Environmental Remediation Costs | Significant Deficiency | Substantially remediated. However, new observations were noted during the current year audit reflected herein as a significant deficiency |

This report is intended solely for the information and use of NASA's management, NASA's Office of Inspector General, OMB, the Government Accountability Office, and Congress, and it not intended to be and should not be used by anyone other than these specified parties.

November 15, 2011

# Report of Independent Auditors on Compliance and Other Matters

**Report of Independent Auditors on Compliance and Other Matters**

To the Administrator and the Inspector General
of the National Aeronautics and Space Administration

We have audited the financial statements of the National Aeronautics and Space Administration (NASA) as of and for the year ended September 30, 2011 and have issued our report thereon dated November 15, 2011. We conducted our audit in accordance with auditing standards generally accepted in the United States of America, the standards applicable to financial audits contained in *Government Auditing Standards,* issued by the Comptroller General of the United States, and Office of Management and Budget (OMB) Bulletin No. 07-04*, Audit Requirements for Federal Financial Statements*, as amended. The management of NASA is responsible for compliance with laws and regulations.

As part of obtaining reasonable assurance about whether the financial statements are free of material misstatement, we performed tests of the compliance with laws and regulations including laws governing the use of budgetary authority, government-wide policies and laws identified in Appendix E of OMB Bulletin No. 07-04 and other laws and regulations, noncompliance with which could have a direct and material effect of the on the financial statements. Under the Federal Financial Management Improvement Act of 1996 (FFMIA), we are required to report whether NASA's financial management systems substantially comply with the Federal financial management systems requirements, applicable Federal accounting standards, and the United States Government Standard General Ledger at the transaction level. To meet this requirement, we performed tests of compliance with FFMIA section 803(a) requirements.

We limited our tests of compliance to the provisions of law and regulation cited in the second paragraph of this report. Providing an opinion on compliance with those provisions was not an objective of our audit, and, accordingly, we do not express such an opinion.

The results of our tests of compliance disclosed no instances of noncompliance or other matters that are required to be reported under *Government Auditing Standards* or OMB Bulletin No. 07-04 and no instances of substantial noncompliance that are required to be reported under FFMIA.

The report is intended solely for the information and use of NASA's management, NASA's Office of Inspector General, OMB, the Government Accountability Office, and Congress and is not intended to be and should not be used by anyone other than these specified parties.

November 15, 2011

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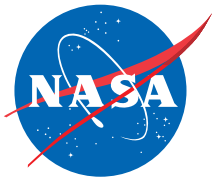
*T: (703)918 3000, F: (703) 918 3100, www.pwc.com/us*

# Management's Response to Independent Auditors Report




National Aeronautics and Space Administration

**Headquarters**
Washington, DC 20546-0001

November 15, 2011

Reply to Attn of:

Office of the Chief Financial Officer

TO: Inspector General

FROM: Deputy Chief Financial Officer

SUBJECT: Management Response to Audit Report of Independent Auditors

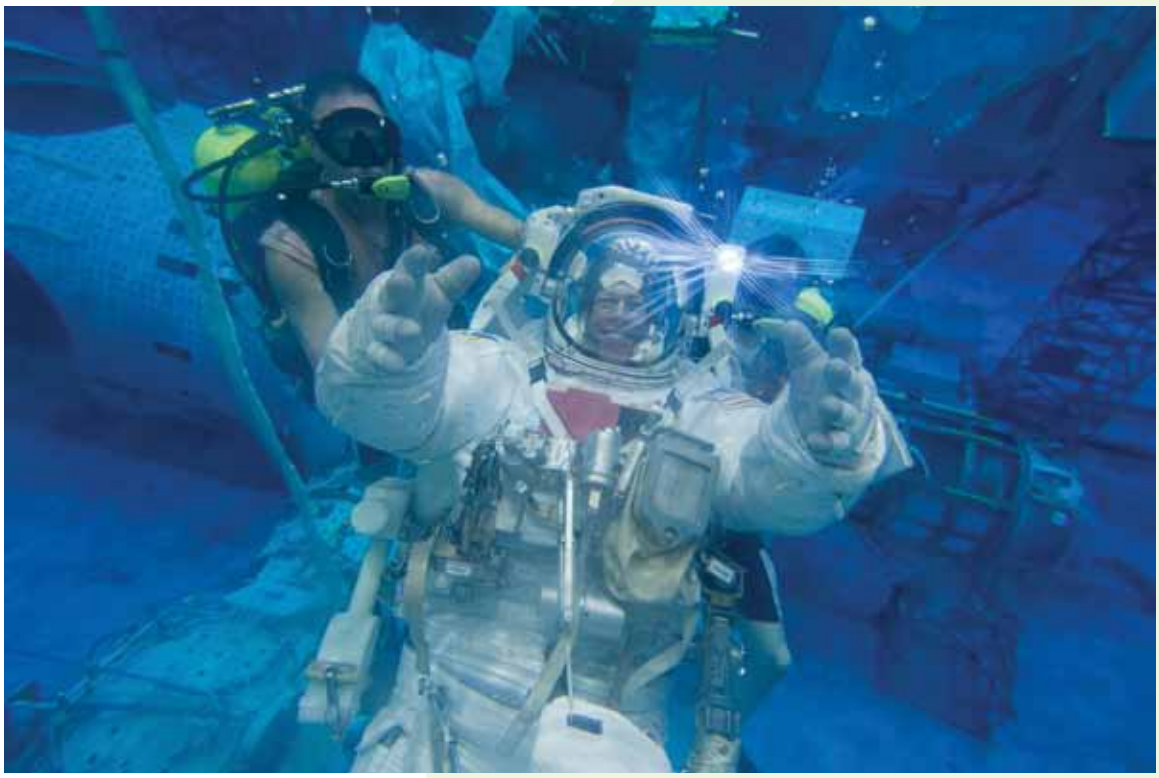
I am pleased to accept your audit report on the Consolidated Financial Statements of the National Aeronautics and Space Administration (NASA) for FY 2011 and FY 2010. The Agency's efforts and achievements toward improved financial management are clearly reflected in the audit opinion. For the first time since 2002, NASA has received an unqualified opinion on its financial statements. The Agency continues to have no material weaknesses for the second consecutive year. Further, we are able to report that NASA continues to be substantially in compliance with the Federal Financial Management Improvement Act.

I am particularly gratified to note the resolution of the prior year significant deficiency in internal control related to legacy property, plant, and equipment. The resolution of this matter is a direct result of the commitment and efforts of the entire Agency. We are proud of the progress that NASA has made toward excellence in financial management.

I appreciate the efforts and leadership of NASA's Office of the Inspector General (OIG) and of the auditors under contract to the OIG to audit NASA's financial statements. Please convey my appreciation and thanks to your team for the professionalism and cooperation exhibited during this audit.

Terry Bowie

# Other Accompanying Information



Photo, previous page: Attired in a training version of his Extravehicular Mobility Unit spacesuit, NASA astronaut Mike Fossum participated in spacewalk training in the waters of the Neutral Buoyancy Laboratory near NASA's Johnson Space Center. Divers in the water assisted Fossum in his rehearsal, which helps prepare him and his fellow astronauts for work on the exterior of the International Space Station. (Credit: NASA)

# Office of Inspector General Letter on NASA's Top Management and Performance Challenges

National Aeronautics and
Space Administration

**Office of Inspector General**
Washington, DC 20546-0001

November 15, 2011

TO: Charles F. Bolden, Jr.
Administrator

FROM: Paul K. Martin
Inspector General

SUBJECT: 2011 Report on NASA's Top Management and Performance Challenges

As required by the Reports Consolidation Act of 2000, this memorandum provides our views of the top management and performance challenges facing NASA and is to be included in the Agency's Performance and Accountability Report for fiscal year 2011.

In determining whether to report an issue as a top challenge, we consider the significance of the issue in relation to the Agency's mission; its susceptibility to fraud, waste, and abuse; whether the underlying problems are systemic; and the Agency's progress in addressing the issue. We previously provided a draft copy of our views to NASA officials and considered all comments received.

Through various initiatives and by implementing recommendations made by the Office of Inspector General (OIG) and other oversight bodies such as the Government Accountability Office, NASA is working to improve Agency programs and operations. However, in our opinion top challenges remain in the following areas:

- The Future of U.S. Human Space Flight
- Project Management
- Infrastructure and Facilities Management
- Acquisition and Contract Management
- Information Technology Security and Governance

This year we removed two issues that appeared on our 2010 list of top challenges: Financial Management and Human Capital. After receiving disclaimers of opinion on its financial statements for the previous 7 years, in 2010 NASA was able to develop sufficient financial evidence and documentation to allow auditors to issue a qualified opinion on the Agency's financial statements. For FY 2011, NASA received an unqualified audit opinion – its first since 2002. Although significant work remains in this area, we believe the Agency's progress over the past several years justifies removing financial management from the list of top Agency challenges.

Similarly, while NASA will always face challenges relating to its workforce, we believe that given the Agency's changing mission its main challenge with respect to Human Capital will be

to ensure continued access to the highly skilled civilian and contractor workforce vital to the Agency's success. Accordingly, we discuss this issue as part of Challenge One – Future of U.S. Space Flight.

During FY 2012 the OIG will conduct work that focuses on NASA's efforts to meet these challenges. We hope that you find our views helpful. Please contact me if you have questions.

Enclosure

# NASA's Top Management and Performance Challenges
# November 2011

## Introduction

Transition remained the key theme at NASA this past year as the Agency's focus shifted away from the Space Shuttle Program to the next phase in the Nation's more than 50 years of space exploration. With the final Space Shuttle mission ending successfully in July 2011, NASA began planning in earnest for the crewed space program called for in the National Aeronautics and Space Administration Authorization Act of 2010 (Authorization Act). At the same time, NASA continues to support the development of commercially operated cargo and crew transportation to the International Space Station (ISS). While the Authorization Act was intended to clarify the future direction of NASA's space program, much of 2011 was marked by congressional concern over the pace and fidelity with which NASA was implementing the law.

Moreover, for the first 6 months of fiscal year (FY) 2011, NASA operated under a continuing resolution that perpetuated language in the 2010 appropriations law prohibiting the Agency from cancelling contracts related to its former rocket and crew vehicle development program even though the program itself had been cancelled by the Authorization Act. As a result, NASA was in the difficult position of having to fund elements of a cancelled program and abide by restrictions that prohibited it from establishing new programs to fully implement the Act's directives. In January 2011, the Office of Inspector General (OIG) sent a letter to the Agency's congressional oversight and appropriations committees urging congressional action to address this situation. The restrictions were finally removed in April 2011.

Adding to the uncertainty of the past year, the viability of NASA's flagship science program – the James Webb Space Telescope (JWST) – has come under intense scrutiny. Although it was well known for some time that JWST was substantially over budget and behind schedule, a NASA review panel's November 2010 findings that the total cost of the Program would exceed $6.2 billion with an earliest possible launch date of September 2015 caused some to question whether the Program should continue. Indeed, the House Appropriations Committee in July 2011 recommended terminating all funding for JWST in NASA's FY 2012 budget. Although the corresponding Senate bill contained money to continue the Program, a final decision on whether and at what level Congress will fund JWST is pending. Moreover, the NASA Administrator has publicly stated that other NASA science and institutional programs will need to be cut in order to offset the funds needed to support JWST.

Finally, like other Federal Government agencies NASA faces significant budget reductions in coming years. For example, the House has proposed $16.8 billion for NASA in FY 2012, $1.6 billion below the 2011 funding level and $1.9 billion below the President's 2012 budget request. The Senate, on the other hand, proposed a FY 2012 funding level of $17.9 billion.

Against this backdrop, we have identified five overarching issues we believe pose the top management and performance challenges to NASA leadership in 2011:

- Future of U.S. Human Space Flight

- Project Management
- Infrastructure and Facilities Management
- Acquisition and Contract Management
- Information Technology Security and Governance

In deciding whether to identify an issue as a top challenge, we considered the significance of the issue in relation to the Agency's mission; its susceptibility to fraud, waste, and abuse; whether the underlying causes are systemic in nature; and the Agency's progress in addressing the challenge. Several of these challenges – specifically project management, acquisition and contract management, and infrastructure and facilities management – are long-standing concerns likely to remain top challenges for the foreseeable future. However, with focused and sustained efforts we believe that NASA can make significant strides in addressing all of the challenges we have identified.

This year we removed two issues that appeared on our 2010 list of top challenges: Financial Management and Human Capital. After receiving disclaimers of opinion on its financial statements for the previous 7 years, in 2010 NASA was able to develop sufficient financial evidence and documentation to allow auditors to issue a qualified opinion on the Agency's financial statements. For FY 2011, NASA received an unqualified or "clean" audit opinion – its first since 2002. Although significant work remains in this area, we believe the Agency's progress over the past several years justifies removing financial management from the list of top Agency challenges.

Similarly, while NASA will always face certain challenges relating to its workforce – for example, ensuring that its employees comply with their ethical responsibilities – we believe that given the Agency's changing mission its main challenge with respect to Human Capital will be to ensure continued access to the highly skilled civilian and contractor workforce vital to the Agency's success. Accordingly, we discuss this issue as part of Challenge One – Future of U.S. Space Flight.

## 1. Future of U.S. Human Space Flight

U.S. human space exploration – NASA's most visible mission since its creation more than 50 years ago – has evolved from the Apollo era to the Space Shuttle and ISS era. With the end of the Space Shuttle Program and the resulting reliance on the Russian Soyuz for astronaut access to the ISS, NASA is embarking on a series of new endeavors, including encouraging development of commercial companies seeking to provide cargo and crew transportation to the ISS and developing new systems and technologies for exploration beyond low Earth orbit.

**International Space Station.** The ISS will play a prominent role in NASA's human space flight activities throughout this decade. However, until commercial companies are capable of providing crew and cargo transportation services, NASA must rely on the Russian Soyuz to ferry astronauts to the ISS and on the Russians and other international partners for ISS cargo resupply missions. Although there are enough on-orbit supplies to sustain the ISS through summer 2012,

Soyuz flights will be the only means to rotate crews and ensure a continued human presence on the ISS for at least the next several years.

Underscoring the tenuousness of the situation, the first vehicle to launch to the ISS in the post-Shuttle era – an unmanned Soyuz rocket carrying three tons of supplies – failed on launch in August 2011. The Russian space agency, Roscosmos, concluded that a blocked fuel line had caused the launch failure and said it plans to return the Soyuz rocket to manned flight in November 2011 with a 3-person crew that includes a NASA astronaut. Indeed, the successful launch of an unmanned Soyuz rocket on October 30 set the stage for this next manned flight. However, corrective actions involving all affected Soyuz flight hardware will impact the schedule of future ISS resupply and crew rotation flights.

A longer-term challenge with respect to the ISS is to ensure that NASA maximizes the productivity and use of the portion of the ISS that operates as a U.S. national laboratory. To that end, NASA has entered into a cooperative agreement – valued initially at $15 million per year – with the Center for the Advancement of Science in Space (CASIS) to manage the national laboratory's capabilities and ensure they are available to the broadest possible cross-section of U.S. scientific, technological, and industrial communities. In the years ahead, NASA must ensure that CASIS develops a varied research and development portfolio based on U.S. national needs for basic and applied research; establishes a marketplace to facilitate matching research pathways with qualified funding sources; and stimulates interest in using the national laboratory for research and technology demonstrations and as a platform for science, technology, engineering, and mathematics education. In addition, NASA needs to continue encouraging use of the ISS by other U.S. Government agencies, other nations, and the commercial sector, while seeking partnerships, cost sharing, and other arrangements to supplement NASA funding of ISS research and operations. The OIG is currently examining NASA's efforts to ensure full utilization of the ISS, including the selection and management of a balanced portfolio of research projects to increase the return on the Government's substantial investment.

**Commercial Launch Providers.** While NASA has over 50 years of experience with contractor-built, Government-owned space vehicles, the Agency has never procured transportation for its astronauts aboard a commercially developed vehicle. Over the past several years, NASA has begun to foster commercial industry with the expectation of developing safe, reliable, and affordable commercial space transportation systems capable of providing cargo and crew transportation services to the ISS and low Earth orbit.

NASA has made sustained progress toward its goal of obtaining commercial cargo and crew transportation services to low Earth orbit. With respect to cargo, NASA has been working to develop commercial providers' capabilities for the past several years and since 2005 has spent $500 million through its Commercial Orbital Transportation Services (COTS) Program. Two companies have entered into funded COTS agreements with NASA: Space Exploration Technologies Corporation (SpaceX) and Orbital Sciences Corporation (Orbital). In FY 2011, NASA requested an additional $312 million – a 62 percent increase above initial COTS estimates – to fund the efforts of these companies, reduce risk, and improve schedule. A series of technical delays postponed SpaceX's first COTS demonstration flight until December 2010, and the first demonstration flight that will actually travel to the ISS, also by SpaceX, is scheduled for early 2012. In October 2011, Orbital announced that delays in NASA's construction and

certification of the Agency's Wallops Island launch complex could delay the company's first launch vehicle test flight originally planned for late December 2011 until late February or early March 2012. Orbital's first COTS demonstration mission to the ISS is scheduled to occur in the second quarter of 2012.

With respect to commercial crew transportation services, in April 2011 NASA announced a second round of Commercial Crew Development (CCDev) awards totaling $269.3 million to four companies – Blue Origin, Boeing, Sierra Nevada Corporation (Sierra Nevada), and SpaceX. NASA has since reported that these companies have successfully met all their initial milestones. Furthermore, NASA has amended its agreements with Boeing and Sierra Nevada by including optional milestones for specific tests of their systems intended to accelerate development efforts. If all milestones are completed successfully, the value of these agreements is $112.9 million and $105.6 million, respectively. Reflecting the new milestones, the manager for NASA's Commercial Crew Program has stated that Sierra Nevada's Dream Chaser spacecraft will make a high-altitude test flight next summer from either Edwards Air Force Base or the White Sands Missile Range.

In July 2011, NASA and United Launch Alliance (ULA) entered into an unfunded Space Act Agreement to share personnel, infrastructure, and information to accelerate the potential use of ULA's Atlas V launch vehicle as part of a commercial crew transportation system. Subsequently, NASA entered into unfunded Space Act Agreements with Alliant Techsystems (ATK) and Excalibur Almaz Incorporated (EAI) to collaborate on the development of ATK's commercial launch system known as Liberty and further the development of EAI's spacecraft concept for low Earth orbit crew transportation.

In September 2011, NASA released an outline of its two-phase acquisition strategy to achieve a certified crew transportation capability from private industry no later than the end of FY 2016. The draft request for proposal calls for a firm-fixed-price Commercial Crew Integrated Design Contract in the first phase to be awarded to one or more companies that will result in a complete end-to-end design compliant with NASA Crew Transportation System requirements, including spacecraft, launch vehicle, launch services, ground and mission operations, and recovery. The contract value could be up to $1.61 billion from July 2012 through April 2014. The Agency anticipates this funding would support one or more contractors. In the second phase, NASA will issue a separate, formal solicitation for follow-on contracts for development, test, evaluation, and certification activities with optional ISS service flights.

NASA's decision to move away from funded Space Act Agreements toward contracts based on the Federal Acquisitions Requirement (FAR), which would allow NASA more control over development, has drawn sharp criticism from some quarters over fears that this acquisition mechanism may cause significant delays and limit the flexibility of participating companies. In rolling out its new strategy, NASA stated that it will use a non-traditional contract approach that will not require certified cost and pricing data and Cost Accounting Standards requirements. In addition, NASA said its proposed procurement approach will allow the companies to tailor their technical approach to NASA's requirements and limit deliverables while NASA adjusts its level of insight and oversight over the contractors as projects move from design and development to certification of the vehicle for flight.

Nevertheless, some industry representatives have expressed concern that NASA's move away from Space Act agreements may be prohibitively expensive, create undue administrative burdens, and curtail the innovation and control they have over their system designs. Conversely, NASA believes the risk that commercial partners' may develop systems that do not meet the Agency's human rating requirements could cause costly and time-consuming redesigns and pose safety concerns, and therefore requires that NASA be more involved in the development of commercial transportation systems.

In a report we issued in June 2011, we identified a series of challenges NASA faces in certifying and acquiring commercial crew transportation services to low Earth orbit.[1] These include: (1) modifying NASA's existing safety and human-rating requirements for commercially developed systems; (2) managing the recently announced acquisition strategy for commercial crew transportation services; (3) implementing the appropriate insight/oversight model for commercial partner vehicle development; (4) relying on an emerging industry and uncertain market conditions to achieve cost savings; and (5) managing the relationship between commercial partners, the Federal Aviation Administration, and NASA. As NASA moves forward in this area, the Agency must strike a balance that will enable innovation and flexibility yet provide the appropriate amount of direct Government involvement to ensure the safety of NASA's astronauts.

At the same time NASA is fostering the development of commercial cargo and crew capabilities to the ISS, Congress has directed the Agency to develop its own launch system and crew vehicle to carry astronauts beyond Earth's orbit. Addressing both of these responsibilities simultaneously will continue to present a significant management challenge for NASA leadership.

**NASA Transportation Systems.** In September 2011, NASA announced the design it will pursue for its next generation Space Launch System (SLS). This new heavy-lift rocket will be capable of more than double the lift capacity of any operational launch vehicle that exists today and will be America's most powerful since the Saturn V rockets that carried Apollo astronauts to the Moon. With an evolvable architecture, the rocket will have an initial capacity of 70 metric tons and eventually be capable of 130 metric tons. Mounted atop the SLS will be the Multi-Purpose Crew Vehicle (MPCV), which is being developed using existing contracts and based on design requirements for the Constellation Program's Orion Crew Exploration Vehicle. The MPCV will serve as the primary crew vehicle for missions beyond low Earth orbit. In addition, the SLS and MPCV will serve as backup crew and cargo transportation to the ISS in the event that international partners and/or commercial space systems are unavailable.

In January 2011, NASA reported that the Reference Design Vehicles that had been chosen for the SLS and MPCV would be unable to meet all requirement and schedule goals or fit into the projected budget profiles contained in the Authorization Act.[2] For example, NASA reported that a 2016 first flight of the SLS, as required by the Act, does not appear to be possible within

[1] NASA OIG, "NASA's Challenges Certifying and Acquiring Commercial Crew Transportation Services" (IG-11-22, June 20, 2011).

[2] NASA, "Preliminary Report Regarding NASA's Space Launch System and Multi-Purpose Crew Vehicle Pursuant to Section 309 of the NASA Authorization Act of 2010 (P.L. 111-267)" (January 2011).

projected funding levels. Instead, NASA plans to conduct the first uncrewed SLS and MPCV test flights in 2017, with the first astronaut crew flying in 2021. In the decades that follow, NASA plans to undertake crewed and robotic missions to a near-Earth asteroid, the Moon, and eventually Mars.

Developing a launch system and crew vehicle, modifying the necessary supporting ground systems, and meeting the NASA Administrator's mandate that exploration systems be affordable, sustainable, and realistic are significant management challenges for NASA leadership. For example, an August 2011 independent cost assessment concluded that NASA's estimates for the SLS, MPCV, and associated ground support programs are reasonable for near-term budget planning but do not support establishment of long-term budgets or detailed baselines consistent with Agency program management requirements.

In an effort to reduce cost during the design phase, NASA focused on reduction of development and operations costs. For example, the SLS will use the same propulsion approach – liquid hydrogen and liquid oxygen – for both the core and upper stages and make use of existing Space Shuttle hardware and technological investments to the greatest extent practicable. Similarly, the MPCV will use much of the current Orion systems design. However, the early cost estimates for the initial SLS and MPCV capability may exceed $18 billion over the next 5 years, including approximately $10 billion for the SLS, $6 billion for the MPCV, and $2 billion for ground support and launch facility modernization at the Kennedy Space Center. The OIG is currently examining NASA's efforts to develop the MPCV as well as its plans to modify the Ares I mobile launcher for use with the SLS, and will continue to focus on these important issues.

**Space Shuttle Transition and Retirement.** After 30 years and 135 missions, NASA's Space Shuttle Program officially ended on August 31, 2011. The Space Shuttle Transition and Retirement Office will now lead all Space Shuttle-related work, including overseeing the preparation of the three retired Orbiters for public display and ensuring unneeded facilities and property are closed, sold, or made available to new users. As discussed above, NASA announced that the new SLS will incorporate technological investments from the Space Shuttle and Constellation programs in order to take advantage of proven hardware and manufacturing technology and reduce development and operations costs. Additionally, NASA plans to retain, for use by the SLS, elements of the Orbiters' main propulsion system, ground support equipment, and other hardware to reduce cost and schedule risks for the new program. These and other activities associated with the end of the Space Shuttle Program represent the largest such transition and retirement effort ever undertaken by NASA. The OIG will continue to examine NASA's management of this complex challenge.

**Launch Vehicles.** The cost and availability of certain classes of launch vehicles needed to support NASA's missions represents a continuing challenge for NASA. For the past decade, NASA and other parts of the U.S. Government have relied on the Atlas V and Delta IV rockets to launch their largest and most important spacecraft. However, retirement of the Space Shuttle and cancellation of the Constellation Program removed a considerable portion of the customer base for the manufacturer of these launch vehicles and has resulted in higher costs for Atlas V and Delta IV component suppliers. Similarly, the Department of Defense's decision to stop using the Delta II – the medium-class vehicle that has been NASA's launch vehicle of choice for nearly 60 percent of its science missions over the last decade – and the decision by ULA to cease

their production has presented NASA with a near-term challenge of finding suitable, cost-effective launch service providers for a number of its science missions.[3] Although new launch vehicles in this class are currently under development, they are unlikely to be ready to launch NASA's science missions until late 2013 or early 2014.

In February 2011, the OIG reported on the projected costs and challenges NASA has faced in finding suitable launch vehicles for its science missions, in particular the medium-class Soil Moisture Active Passive (SMAP) mission scheduled to launch in November 2014.[4] The report highlighted the disparity in performance and launch services costs between currently available launch vehicles, such as Minotaur and Atlas V, and the estimated costs of launch vehicles under development. Because NASA had not selected a launch vehicle for the SMAP mission as of early November 2011, the project's launch is likely to be delayed.

The issue of increasing cost and availability of launch vehicles is not limited to the SMAP mission. For example, the costs to launch NASA's Mars Atmosphere and Volatile Evolution Mission to Mars in 2013 are $187 million. This compares to the $124 million that NASA negotiated 4 years ago to launch the Landsat Data Continuity Mission (scheduled to launch in December 2012) using the same Atlas V launch vehicle. Furthermore, these costs are predicted to continue increasing by as much as 30 percent for launches occurring in 2018. In addition, the Government Accountability Office (GAO) reported that the Joint Polar Satellite System (JPSS-1), and the Ice, Cloud, and Land Elevation Satellite (ICESat-2) missions are approaching their preliminary design reviews but have not yet identified a suitable launch vehicle.[5] Because changing launch vehicles after preliminary design review often results in substantial cost increases and schedule delays, the report states that NASA is likely to make a launch vehicle decision, prior to having certified as safe for flight, vehicles that are in development and accept any resulting cost and schedule impacts resulting from the certification process. While NASA has estimated the costs associated with the certification process and potential technical issues that could arise during that process, these costs are not covered under existing budgets.

The issues surrounding launch vehicle availability have been exacerbated by two recent failures of the Taurus XL rocket. On February 24, 2009, NASA's Orbiting Carbon Observatory was lost when the payload fairing, a clamshell-shaped cover that encloses and protects the satellite, failed to separate during the rocket's ascent. Similarly, the Glory satellite was lost on March 4, 2011, when the same fairing, which had been modified after the last failure, again failed to separate. After the March 2011 failure, NASA stopped payment on the contract for the Taurus XL rocket it had planned to use to launch the Orbiting Carbon Observatory-2 satellite in February 2013. Consequently, NASA has put this launch on hold, which will undoubtedly result in increased project costs.

In September 2010, NASA announced its NASA Launch Services (NLS) II indefinite-delivery-indefinite-quantity contracts as the primary means to acquire launch services through 2020.

[3] Medium-class missions are typically satellite payloads between 1,500 and 3,200 kilograms (3,300 to 7,040 pounds), respectively, launched to a 675-kilometer (approximately 405 miles) orbit around the Earth.

[4] NASA OIG, "Review of NASA's Acquisition of Commercial Launch Vehicles" (IG-11-012, February 17, 2011).

[5] GAO, "NASA: Medium Launch Transition Strategy Leverages Ongoing Investments but Is Not Without Risk" (GAO-11-107, November 22, 2010).

Under NLS II, NASA awarded contracts to Lockheed Martin for the Athena I and II, Orbital Sciences for the Pegasus XL and Taurus XL, SpaceX for the Falcon 1 and 9, and ULA for the Atlas V. In September 2011, the Agency modified the NLS II contract to make available the five remaining Delta II rockets in ULA's inventory. However, these vehicles can only be launched from Vandenberg Air Force Base in California because the Delta II launch pad at Cape Canaveral in Florida is no longer maintained.

To provide some stability for the launch vehicle industrial base and take advantage of new launch capability, NASA, the National Reconnaissance Office, and the U.S. Air Force recently signed two agreements. The first is a memorandum of understanding, signed in March 2011, intending to stabilize the current Evolved Expendable Launch Vehicle (Atlas V and Delta IV) industrial base. The second, signed in October 2011, is an agreement on a coordinated strategy to establish clear criteria for certification of commercial providers of launch vehicles used for national security space and civil space missions. The intent of this coordinated strategy is to further competition and provide a consistent path for new entrants to compete for U.S. Government missions. This approach is characterized by a risk-based certification framework – already in use by NASA – which provides a methodology for certification of launch vehicles based on the risk tolerance of each payload.

**U.S. Space Industrial Base.** The recent changes in the direction of NASA's human space flight program may adversely affect the U.S. space industrial base and associated supply chain. Retirement of the Space Shuttle, cancellation of the Constellation Program, and the debates over development of a new space transportation system and the amount of funding that should be dedicated to commercial partner activities could negatively impact the Agency's ability to retain the manufacturing and technological capabilities, skilled workforce, and supply chains necessary to meet NASA's missions. For example, in December 2009 the White House Office of Science and Technology Policy reported that Government and commercial long-term requirements are insufficient to drive significant private sector investment in new propulsion capabilities and technologies. Additionally, in 2010 a Department of Commerce survey of NASA's supply chain network found that an estimated 28,000 jobs may be lost nationwide as a result of Space Shuttle retirement, Constellation transition, and the projected gap in procurements for future human space flight systems.

Historically, the design, development, and production of space systems have involved low production quantities, a high degree of specialization, and dependence on a uniquely skilled and highly qualified workforce. But many smaller vendors involved in the process cannot easily accommodate changes in schedule, funding levels, or requirements for low-production items. In addition, domestic and foreign competition, variability of demand, and skills retention have significantly reduced the domestic supplier base available to NASA. In fact, many of NASA's long-standing industry partners have already faced steep layoffs as new partners struggle to cut costs and make emerging space systems more affordable. While the September 2011 announcement of plans to move forward developing the SLS may help mitigate some of these issues, NASA must address these significant challenges as it seeks to build new space capabilities.

## 2. Project Management

Effective project management is critical to NASA's ability to achieve its overall mission, but systemic weaknesses in this area have proven a long-standing challenge for the Agency. The OIG is focusing increased attention on this issue to help ensure that NASA is actively addressing the challenges associated with developing and operating its space and science missions. Specifically, the OIG is conducting a review of NASA's project management practices to identify the root causes affecting project managers' ability to meet cost, schedule, and performance expectations.

**Cost and Schedule Estimates.** Historically, NASA has struggled with establishing realistic cost and schedule estimates for the projects in its portfolio. Both the OIG and GAO have repeatedly cited cost growth and schedule slippage in the Agency's major projects. This is often due to the Agency's failure to address systemic project management challenges related to requirements growth, cost estimating, technology development, and partner performance.

For example, in March 2011 GAO released its assessment of 21 large-scale NASA projects with a combined life-cycle cost exceeding $68 billion. GAO found that 13 projects for which NASA established baselines prior to 2009 experienced an average development cost growth of almost 55 percent, with a total increase in development costs of almost $2.5 billion from their original baselines.[6] GAO attributed this cost and schedule growth in part, to the Agency's failure to adequately identify and provide funding to match technological complexities.

Perhaps no project is more emblematic of the scope of the Agency's project management challenges than the JWST, NASA's most expensive and technologically complex science project, is now projected to cost $8.8 billion and to launch in October 2018, significantly above its original life-cycle cost baseline estimate of $5 billion and later than the original launch date of June 2014. Similarly, in June 2011 the OIG reported on cost and schedule issues with NASA's Mars Science Laboratory (MSL) Project.[7] Because of management's failure to accurately estimate the resources required to address MSL's complex technical issues, the launch was delayed approximately 2 years to November 2011, development costs increased by 86 percent (from $969 million to the current $1.8 billion), and the project's life-cycle costs increased by 56 percent (from $1.6 billion to the current $2.5 billion).

Partner-related issues have also contributed to cost growth and schedule delays in NASA projects. For example, the National Polar-orbiting Operational Environmental Satellite System Preparatory Project (NPP), which the OIG reported on in June 2011, experienced a 54 percent increase in costs and a 5-year launch delay.[8] Originally planned for an October 2006 launch with a life-cycle cost of $560 million, NPP successfully launched on October 28, 2011, with life-cycle cost growth to $864 million. Although NASA met its schedule and technical requirements for producing the NPP spacecraft and the instruments for which it was responsible, the other partners involved in the project – the Department of Defense and the National Oceanic and

[6] GAO, "NASA: Assessments of Selected Large-Scale Projects" (GAO-11-239SP, March 3, 2011).

[7] NASA OIG, "NASA's Management of the Mars Science Laboratory Project" (IG-11-019, June 8, 2011).

[8] NASA OIG, "NASA's Management of the NPOESS Preparatory Project" (IG-11-018, June 2, 2011).

Atmospheric Administration – were unable to deliver their scientific instruments to NASA in a timely manner, thereby resulting in additional costs to NASA. GAO reported similar challenges related to NASA's partnership with the Space Agency of Argentina, Comisión Nacional de Actividades Espaciales (CONAE), on the Aquarius mission. This project, whose goal is to measure sea surface salinity and provide the global view of salinity variability that is needed for climate studies, was delayed approximately 2 years and cost NASA $40 million more than the baseline estimate due to delays by CONAE in developing the spacecraft and propulsion system thrusters. Moving forward, NASA's challenge will be to strike a balance between collaborating with other Federal Government agencies and international partners while minimizing the resource impact on NASA should a partner fail to timely meet its responsibilities.

**Project Management Principles and Tools.** To execute projects within established cost and schedule estimates, NASA needs to maximize the use of sound project management principles in projects both large and small. These principles are codified in Agency-wide policies that establish the requirements by which NASA should formulate and implement space flight programs and projects. As discussed above, the JWST project illustrates NASA's difficulty in applying these principles to a major science project. However, the challenge for NASA in successfully applying these project management principles extends beyond its multi-billion dollar projects. For example, in September 2011 the OIG issued its review of the Advanced Radiation Instrumentation Project, a suite of instruments designed to monitor astronauts' exposure to radiation while aboard the ISS, that found managers did not follow established policies.[9] Consequently, the Project incurred significant cost increases, schedule delays, and was de-scoped to exclude some planned elements.

While effective project management historically has been a major challenge for NASA, the Agency has shown that it can use project management tools, such as earned value and risk management, to produce positive results. For example, in reviewing NPP we found that managers implemented an earned value management system to track the development of the instruments NASA was responsible for producing and implemented risk management procedures to identify, analyze, track, and communicate associated risks. As a result, NASA's instruments were ready in time for the original October 2006 launch, management proactively took steps to mitigate partner delays by performing risk reduction tests on individual instruments upon delivery as opposed to waiting until the integration phase as originally planned, and the final ground and integration testing was accomplished on schedule and within budget. Conversely, we found that MSL Project managers consistently underestimated costs and did not identify and assess all risks associated with problems and failures and consequently experienced significant cost growth and schedule delays. Going forward, NASA's challenge will be to consistently employ these and other tools to improve cost estimating on all Agency projects.

[9] NASA OIG, "A Review of NASA's Replacement of Radiation Monitoring Equipment on the International Space Station" (IG-11-027, September 29, 2011).

## 3. Infrastructure and Facilities Management

NASA is the ninth largest Federal Government property holder, controlling a network of approximately 5,400 buildings and structures that support Agency research, development, and flight activities. In total, the assets occupy 44 million square feet and represent more than $29 billion in current replacement value. The Authorization Act requires NASA to examine its structure, organization, and institutional assets and develop a strategy for the most efficient retention, sizing, and distribution of facilities and other infrastructure consistent with NASA's mission. NASA's ability to effectively manage its large and aging portfolio of facilities is a critical and long-standing challenge for the Agency.

**Maintenance, Repair, and Use of Aging Facilities.** For years, NASA has struggled with its aging and underutilized infrastructure and the related issue of managing its backlog of deferred maintenance projects. NASA officials report that more than 80 percent of the Agency's facilities are 40 or more years old and beyond their design life. Under its current policy, NASA is required to maintain these facilities to keep them operational or, if they are not being used, to ensure they do not pose a safety hazard. The Agency estimated its deferred maintenance costs for 2011 at $2.47 billion.[10]

The Aerospace Safety Advisory Panel cited NASA's aging facilities as an area of concern in its most recent annual report, and in a 2010 report the National Research Council cited a "steady and significant decrease in NASA's laboratory capabilities, including equipment, maintenance, and facility upgrades" that require more maintenance than funding permits. For several years, Congress has cited NASA's backlog of maintenance and repair projects as an area of concern. For example, NASA's 2008 Authorization Act directed the Administrator to "determine and prioritize the maintenance and upgrade backlog at each of NASA's Centers and associated facilities, and develop a strategy and budget plan to reduce that maintenance and upgrade backlog by 50 percent over the next 5 years." However, according to Agency officials, funding constraints over the years have resulted in little reduction in NASA's backlog of deferred maintenance projects.

In March 2011, we issued an audit report in which we reported that NASA's ability to plan for and achieve a reduction in its maintenance backlog is hindered by the lack of reliable facilities maintenance cost data.[11] At the time of our fieldwork, NASA used multiple and inconsistent mechanisms for capturing costs associated with facilities maintenance work. In addition, without proper preparation and use of planning documents, NASA maintenance managers could not effectively assess anticipated maintenance needs across the agency or effectively compete for funding with other Center support services. Similarly, an August 2011 OIG report examined the accuracy of data contained in NASA's primary system for compiling and analyzing the Agency's real property assets and found that the data relating to utilization, mission dependency, and

[10] NASA, "Deferred Maintenance Assessment Report: FY11 NASA-Wide Standardized Deferred Maintenance Parametric Estimate (Full Assessment)," October 1, 2011.

[11] NASA OIG, "Audit of NASA's Facilities Maintenance" (IG-11-015, March 2, 2011).

condition were unreliable metrics for evaluating NASA's real property assets, largely because NASA Centers used inadequate processes to gather and update the information.[12]

The challenge for NASA leadership in this area is to reduce the backlog of essential maintenance projects. Failure to do so will further increase the risk that Agency facilities will not be available for future use or may create additional risks to the safety of personnel and equipment and the accomplishment of NASA's missions. Moreover, continuing to "kick the can down the road" is likely to result in higher costs to repair these facilities in the future.

**Master Planning for Facilities Needs**. To make the strategic decisions necessary to address its infrastructure challenges, NASA is developing its first integrated, Agency-wide real property Master Plan. NASA began developing this Master Plan in early 2011 and expects to complete it by the end of the year. NASA intends to use the Plan to coordinate resources across the Agency, link real property needs with projected funding to support NASA programs and strategic objectives, and gain efficiencies by eliminating facilities that no longer benefit the Agency.

The development of an Agency-wide Master Plan was the result of NASA's efforts to revise its facility strategy to reduce the Agency's infrastructure footprint. In response to the Authorization Act, NASA is preparing a strategy document that describes the facilities renewal approach adopted in 2009 by the Agency, known as the "similar/smaller strategy," with a goal to reduce each Center's current replacement value by 10 percent by 2020 and 15 percent by 2050.

The Agency faces significant challenges as it works to meet current and future mission requirements and to comply with the intent of the Authorization Act to downsize its infrastructure to fit current and future missions and expected funding levels. Given the importance of the Agency-wide Master Plan to this process, the OIG is conducting a review to determine (1) whether NASA has an effective overall Agency-wide Master Plan; (2) whether Center master plans align with the Agency's goal to reduce its real property footprint; and (3) whether NASA has an effective approach for prioritizing projects for construction of facilities funding.

**Reducing Unneeded and Duplicative Infrastructure.** NASA has more real property than necessary to meet its mission, and in the last 2 decades numerous studies have stressed the need for NASA to reduce its infrastructure. In the1990s, GAO issued several reports on NASA's challenges to achieving reductions and efficiencies in its infrastructure and noted that NASA was building new facilities faster than it was consolidating or closing older ones, resulting in major areas of duplication of capabilities. In May 2007, GAO reported that over 10 percent of NASA's real property assets were not being utilized at all or were underutilized.[13] In 2008, NASA's own Program Analysis & Evaluation (PA&E) Office identified 203 facilities that had no future mission requirement. Finally, in an August 2011 audit, we found numerous NASA facilities that had not been utilized, some for as long as 10 years.[14]

[12] "NASA Infrastructure and Facilities: Assessment of Data Used to Mange Real Property Assets" (IG-11-024, August 4, 2011).

[13] GAO, "Federal Real Property: An Update on High-Risk Issues"( GAO-07-895T, May 24, 2007).

[14] NASA OIG, "NASA Infrastructure and Facilities: Assessment of Data Used to Manage Real Property Assets" (IG-11-024, August 4, 2011).

The challenge for NASA leadership in this area is to identify and reduce unneeded and duplicative property in light of the costs associated with facility disposal or consolidation, the varying mission requirements of each Center, and the political pressures to retain or build the mission capabilities of specific Centers. To determine which facilities NASA can eliminate in the future, NASA management must focus on identifying the key missions, technologies, and programs that NASA intends to pursue over the next 20 to 30 years. Beyond the strategic plan, NASA must identify strategic goals with enough specific detail to facilitate identifying unneeded facilities and eliminate the conservative "keep it in case we need it" approach to managing its facilities.

Given the likelihood of constrained budgets, it is imperative that NASA take action to evolve toward the most efficient facility structure for its future. To assist in this effort, in September 2011 the OIG initiated a review to examine NASA's efforts to identify and reduce the Agency's unneeded and duplicative research and development facilities, focusing initially on wind tunnels and test stands.

**Leased Space at NASA Centers.** NASA's excess of real property presents considerable challenges for the Agency in its efforts to address the maintenance needs of its aging facilities. Leasing offers the Agency a means to help address this challenge. Leasing should not be used as a rationale to retain unneeded or duplicative infrastructure; however, NASA could generate revenue to offset facilities operations and maintenance costs and potentially reduce some of its $2.47 billion deferred maintenance liability by leasing underutilized but essential facilities to external entities.

One tool available to NASA is Enhanced-Use Leasing (EUL), which allows NASA to retain and use the proceeds derived from the leasing of underutilized real property. In FY 2003, Congress granted EUL authority to Ames Research Center and Kennedy Space Center, allowing those Centers to out-lease underutilized real property and retain the proceeds for facilities projects. This authority includes a provision for in-kind payment in the form of facility upgrades or other services in lieu of cash. For example, Kennedy has an EUL with a Florida utility for a 60-acre site that supports a solar farm that is integrated into the Center's power grid and generates 1 percent of the Center's power needs. The FY 2008 Appropriations Act expanded NASA's EUL authority to all NASA Centers beginning December 31, 2008. However, the Act required the leases to be cash only and prohibited Centers from accepting in-kind payments. NASA officials have indicated that allowing all Centers to accept in-kind consideration would be helpful to their facilities management efforts.

The OIG initiated a review in July 2011 to examine the effectiveness of NASA's management of its lease agreements. In this review, we are assessing whether NASA is effectively identifying space available to lease, whether NASA's leasing activities are beneficial to NASA and the Government, whether NASA has improved internal controls to account for in-kind consideration for EULs, and whether NASA is recouping all appropriate costs under the terms of lease agreements.

## 4. Acquisition and Contract Management

Approximately 83 percent of NASA's $18.7 billion FY 2010 budget was spent on contracts to procure goods and services and provide funding to grant and award recipients. Accordingly, it is critical that NASA use the most advantageous acquisition and award strategies to promote competition and ensure the billions of dollars of taxpayer funds entrusted to it are spent wisely. However, systemic weaknesses in NASA's internal controls related to acquisition and contracting continue to create challenges for the Agency. The OIG will continue to focus resources on this issue to identify instances of fraud, waste, and abuse by contractors and awardees as well as weaknesses in the Agency's system of internal controls.

**Contract Management.** Given the large amount of taxpayer funds it spends on contract awards, Agency managers are constantly challenged to ensure that NASA pays contractors in accordance with contract terms and receives fair value for its money. Indeed, the OIG's investigative work continues to uncover fraud and overcharging by NASA contractors. For example, this past year a Michigan-based firm agreed to pay $800,000 to resolve allegations that it fraudulently obtained a contract with NASA's Plum Brook Station by misrepresenting its eligibility for a Service-Disabled Veteran-Owned Small Business set-aside. Similarly, a joint investigation with other government agencies identified a group of communications service providers who had improperly billed NASA and other customers over an extended period of time for telephone systems and equipment that did not function properly and for maintenance on those systems after they had been replaced. This case resulted in a $13 million repayment by the contractors to the United States.

One area in which NASA has been particularly challenged with regard to safeguarding against fraud is its Small Business Innovation Research (SBIR) Program. Between 2004 and 2008, NASA awarded an average of $112 million annually to small businesses under this Program to stimulate technological innovation, increase participation by small businesses in federally funded research and development, and increase private-sector commercialization of innovations derived from federally funded research and development efforts. In multiple investigations over the years, the OIG has indentified significant fraud, waste, and abuse in NASA's SBIR Program. For example, this past year an OIG investigation resulted in the criminal convictions of a University of Florida professor and his wife who had submitted fraudulent proposals to obtain more than $3 million in SBIR contracts with NASA and the Air Force. Although the defendants claimed their company would provide NASA with research from scientists and engineers working in a state-of-the-art analysis and data communication laboratory, in reality they simply submitted the work of graduate and doctoral students at the University, without the students' knowledge or approval. In another case, a small business submitted the same or very similar research proposals to multiple Federal agencies and received more than $373,000 in SBIR contract awards for the same or similar work.

Based on these and other similar OIG investigations, the OIG conducted an audit in 2011 examining the internal controls in NASA's SBIR Program.[15] We found that while NASA's methods of choosing SBIR award recipients appeared objective and merit-based, its oversight

[15] NASA OIG, "Review of NASA's Management of Its Small Business Innovation Research Program" (IG-11-010, January 12, 2011).

and monitoring of awards was deficient. Specifically, SBIR awards in 2008 contained an estimated $2.7 million in unallowable and unsupportable costs, including travel and equipment expenses. We also found that because NASA had not implemented appropriate internal controls in the SBIR Program, some SBIR award recipients may have received multiple SBIR awards from different Federal agencies for the same research, or NASA may have received highly questionable research products for its money. As part of our audit work, we developed a data-mining tool that NASA and other Federal agencies with SBIR programs are using to help identify SBIR fraud. We also made several recommendations to the SBIR Program to implement new processes or procedures to improve verification of contractor performance and protect against potential fraud earlier in the review and selection process. Based on recent discussions with Program personnel, we believe the Agency is making strides toward implementing these recommendations.

**Grant Management.** NASA faces the ongoing challenge of ensuring that the approximately $550 million in grant funds it awards annually are administered appropriately and that recipients are accomplishing stated goals. Over the past 5 years, the OIG has conducted 37 grant fraud investigations resulting in 3 prosecutions and $10.1 million in restitution and recoveries. In a recent case, an OIG investigation found that a grant to Morehouse College had been improperly used to fund an employee's personal travel and to purchase equipment and services unrelated to the purpose of the grant. As a result of this investigation, Morehouse College agreed to pay $1.2 million in a civil settlement to the Government.

During FY 2010, NASA awarded $1.7 billion in procurement actions to educational and other nonprofit institutions, including $557 million (33 percent) in grant awards. This financial assistance was awarded to recipients to facilitate research and development projects; to fund scholarships, fellowships, or stipends to students, teachers, or other faculty; and to fund educational research performed by educational institutions or other non-profit organizations. In September 2007, the OIG reported weaknesses in the Agency's administration and management of its education and training grants. Specifically, the OIG found that grant recipients had misspent grant funds because of the Agency's lack of oversight at the recipient level. Four years later, in a September 2011 report, the OIG identified weaknesses in NASA's oversight of its grant award process and continued weaknesses in the monitoring of grantee performance. The lack of proper oversight contributes to a heightened risk that grant objectives will not be met and grant funds may be misused.

NASA is faced with the challenge of enhancing its level of oversight to its grant recipients while balancing resource limitations and budget constraints. We will continue to focus OIG resources in this area as the Agency takes steps to address our recommendations and enhance its processes for managing its grant awards.

## 5. Information Technology Security and Governance

NASA information technology (IT) systems and networks control spacecraft, collect and process scientific data, and enable NASA personnel to collaborate with their colleagues around the world. Over the past decade, NASA has become dependent on computerized information

systems to carry out daily operations and to process, maintain, and report essential information. Although most NASA IT systems contain data that may be widely shared, some contain sensitive information which, if released or stolen, could result in significant financial loss or adversely affect national security. Accordingly, it is imperative that NASA properly protect its IT systems and networks.

**IT Security Weaknesses.** Over the past several years, OIG reviews have identified a recurring theme of poor management processes and inadequate operational and technical controls that affect NASA's ability to protect the information and information systems vital to its mission.

As part of our FY 2011 Federal Information Security Management Act (FISMA) audit, we found that NASA had not fully implemented key requirements needed to adequately secure Agency information systems and data. For example, NASA has not fully developed a comprehensive governance structure and Agency-wide risk management strategy, and the Office of the Chief Information Officer (OCIO) could not provide us with evidence that the Agency has an active risk assessment process specific to information security. Until NASA improves its IT security practices by completing a comprehensive IT security risk assessment, the Agency is vulnerable to computer incidents that could have a severe or even catastrophic effect on Agency assets and operations.

We also found that the OCIO has not effectively managed corrective action plans to prioritize mitigation of IT security weaknesses. This occurred because the OCIO did not have a formal policy for managing the plans and did not follow recognized best practices when it purchased an information system intended to facilitate Agency-wide management of IT corrective action plans. We found that the information system was significantly underutilized and therefore was not an effective tool for managing corrective action plans.

Through our audits and assessments during the past year, the OIG has found significant and recurring internal control weaknesses in NASA's IT security control monitoring and cyber-security oversight. For example, although NASA has made progress in transitioning to a continuous monitoring program, the Agency still needs to (1) create and maintain a complete, up-to-date record of IT components connected to its networks; (2) define the security configuration baselines that are required for its system components and develop an effective means of assessing compliance with those baselines; and (3) use credential scanning as part of vulnerability management on all its IT systems. We also found that NASA's network defenses and incident detection capability could neither prevent nor detect sophisticated but increasingly common types of cyber attacks that target sensitive data on the Agency's computer networks.

Specifically, we found that six computer servers associated with IT assets that control NASA spacecraft and contain critical data had vulnerabilities that would allow a remote attacker to take control of or render them unavailable. Moreover, once inside the Agency network, the attacker could use the compromised computers to exploit other weaknesses we identified, a situation that could severely degrade or cripple NASA operations. Finally, NASA has not established an alternate or backup Agency-wide incident detection capability for its Security Operations Center. If the Security Operation Center became unavailable, NASA's ability to detect and promptly respond to cyber attacks against Agency computer systems and networks could be severely degraded.

**Attacks on IT Infrastructure.** Attacks on NASA's IT infrastructure occur regularly. In 2009 and 2010, NASA reported 5,621 computer security incidents that resulted in the installation of malicious software on Agency systems or unauthorized access to its computers. Such incidents disrupt Agency operations and can result in the loss or theft of sensitive data from NASA computer systems.

NASA remains a target both because of the large size of its networks and because its information is highly sought after by criminals attempting to steal technical data or further other criminal activities. Moreover, the attacks are becoming more sophisticated and harder to detect and remediate. For example, an OIG investigation initiated in September 2008 led to the prosecution of a U.S. citizen who had gained the highest level of access to two NASA web servers that contained scientific weather data used by more than 3,000 individuals each day. As a result of the intrusion, the server had to be taken off line for 19 days resulting in at least $66,000 in mitigation and repair costs. In other recent OIG investigations, we identified Chinese, Swedish, and British citizens as the individuals responsible for compromising various NASA IT systems.

As the threat expands and the sophistication of the attacks increases, NASA will continue to be challenged to ensure that its IT security is sufficiently robust.

**NASA IT Governance.** Achieving the Agency's IT security goals will require sustained improvements in NASA's overarching IT management practices and governance. Effective IT governance is the key to accommodating the myriad interests of internal and external stakeholders and making decisions that balance compliance, cost, risks, and mission success. Federal law and NASA policy designate the Headquarters-based Chief Information Officer as the NASA official responsible for developing IT security policies and procedures and implementing an Agency-wide IT security program. However, we have found that the Chief Information Officer has limited ability to direct NASA's Mission Directorates to fully implement IT security programs. As a result, key Agency computer networks and systems operated by the Mission Directorates do not consistently comply with Agency IT policy.

In October 2011, NASA adopted an IT governance model to streamline decision making for and prioritization of strategic IT investments across the Agency. However, our review of NASA's IT governance model reveals limited involvement of Mission Directorate senior officials in NASA's in IT security decisions. Moreover, the model does not incorporate IT security policy as a key element when evaluating significant IT investments. Until NASA incorporates IT security policy into its IT governance model and fully implements related IT security programs, the Agency will continue to be at risk for security incidents that can have a severe adverse effect on Agency operations and assets.

# FY 2011 Inspector General Act Amendments Report

## Background

The Inspector General Act Amendments of 1988 (P.L. 100-504), require that each agency head submit semi-annual reports to Congress on the actions taken in response to Office of Inspector General (OIG) audit, evaluation, and inspection reports. Consistent with the Reports Consolidation Act of 2000 (P.L. 106-531), the National Aeronautics and Space Administration (NASA) consolidates and annualizes the required semi-annual Inspector General Act Amendments reporting elements for inclusion in the annual Performance and Accountability Report (PAR).

Required agency reporting under the 1988 amendments consists of:

1. Disclosure of OIG reports containing findings with monetary benefits (i.e., disallowed costs and funds put to better use):

- **for which management decisions were made during the reporting period (FY 2011);**
- **for which final management decisions have been made, but final management action is pending;**
- **for which final management action was taken during the reporting period, and;**
- **for which no final management action was taken during the reporting period.**

2. Disclosure of OIG audit reports issued in prior fiscal years (pre-FY 2010) for which final management action is pending, but not yet completed.

In addition to above statutory requirements, the Office of Management and Budget (OMB) has issued specific action requirements to federal agencies in their Circular No. A-50, "Audit Follow-up." These requirements include among other things that federal agencies ensure that final management decisions on audit recommendations are reached within six months after an OIG audit report is issued and that related corrective action associated with the final management decision begin as soon as possible.

The following definitions are provided to enhance the readability of NASA's FY 2011 Inspector General Act Amendments Report:

**Final Management Decision** is reached when management evaluates the OIG's findings and recommendations and determines whether or not to implement a proposed recommendation.

**Final Management Action** is the point in time when corrective action, taken by management in conjunction with a final management decision, is completed.

Corrective Action consists of remediation efforts on the part of management which are intended to mitigate an audit finding.

**Questioned Costs** are those identified by the OIG as being potentially unallowable or unallocable because of: (a) an alleged violation of a provision of a law, regulation, contract, grant, cooperative agreement, or other agreement or document governing the expenditure of funds; (b) a finding that, at the time of the audit, such cost is not supported by adequate documentation; or (c) finding that the expenditure of funds for the intended purpose is unnecessary or unreasonable.

**Disallowed Costs** are questioned costs that management has sustained or agreed should not be charged to the Government.

**Funds Put to Better Use (FPTBU)** are funds that could be used more efficiently if management implemented an audit recommendation. Efficiencies may result from: (a) reductions in outlays; (b) de-obligation of funds, or (c) costs not incurred by implementing recommended improvements related to operations of the agency, a contractor, or a grantee.

# NASA's Audit Follow-up Program

NASA is committed to ensuring timely and responsive final management decisions along with timely and complete final management action on audit recommendations issued by the NASA OIG. NASA management believes that audit follow-up is essential to improving the efficiency and effectiveness of NASA's programs, projects, and operations. In this regard, NASA has implemented a comprehensive program of audit liaison, resolution, and follow-up intended to ensure that audit recommendations issued by the OIG are resolved and implemented in a timely, responsive, and effective manner.

NASA has designated the Office of Internal Controls and Management Systems (OICMS) as the Agency's office of primary responsibility for policy formulation, oversight, and functional leadership of NASA's audit liaison, resolution and follow-up program. OICMS implements program activities through an Agency-wide network of Audit Liaison Representatives (ALRs), who, in turn, are responsible for executing program activities at the operating level. This network of ALRs, in conjunction with OICMS oversight, provides the organizational structure to support NASA's audit liaison, resolution, and follow-up program. Program activities are tracked, monitored and reported through the utilization of NASA's Audit and Assurance Information Reporting System (AAIRS). AAIRS is a web-based tracking and reporting tool utilized by OICMS and NASA ALRs to monitor key activities and milestones associated with audits performed by the OIG.

In accordance with requirements delineated in OMB Circular A-50, OICMS monitors audit recommendations issued by the OIG to ensure that a final management decision is reached within six months of the issuance of a final audit report. A final management decision consists of either agreeing to implement an OIG recommendation; agreeing to implement a portion of an OIG recommendation, or; declining to implement an OIG recommendation. In those instances where agreement between the OIG and NASA management cannot be reached, a final management decision will be sought from NASA's Audit Follow-up Official (AFO) within six months of the issuance of a final audit report.

Once a final management decision has been made to either implement or partially implement an OIG audit recommendation, corrective action on the part of management is pursued as rapidly as possible, in accordance with provisions of OMB Circular A-50. On occasion, the corrective action associated with a final management decision spans multiple fiscal years. This may be due to the complexity of the planned corrective action (which often times consists of the design, implementation, and testing of related systems or sub-systems); or the development, concurrence and review process associated with the issuance of NASA policy and/or procedural requirements. NASA management continues to aggressively pursue the implementation of agreed-upon corrective action relating to audit recommendations issued by the OIG.

The Inspector General Act Amendments of 1988 require that heads of federal agencies report on actions taken, or remaining to be taken, in response to OIG audit reports containing monetary findings. The amendments also require that management disclose those OIG audit reports for which a final management decision had been made in a prior reporting period, but where final management action is still pending. In addition to the statutory reporting requirements delineated in the Inspector General Act Amendments of 1988, OMB Circular A-50, requires that final management decisions on OIG audit recommendations be made within six months of the issuance of a final audit report. NASA's reporting in conjunction with the requirements of the Inspector General Act Amendments of 1988 and OMB Circular A-50 follows:

# FY 2011 Audit Follow-up Results

## 1. OIG Audit Reports with Monetary Findings

During FY 2011, the OIG issued six audit reports containing monetary findings with questioned costs (potentially disallowed costs) totaling $7,516,615 and "funds to be put to better use" in the amount of $107,100,000. Of the $7,516,615 in OIG questioned costs, NASA sustained $371,612[1] as disallowed costs. Remaining questioned costs in the amount of $7,145,003 are pending final management action at September 30, 2011.

Of the $107,100,000 in OIG identified "funds to be put to better use," NASA has implemented $1,858,059[2] with $93,800,000 of OIG identified "funds to be put to better use" still pending final management action as of September 30, 2011.

There were no prior year OIG reports with monetary findings requiring final management action at the beginning of FY 2011 (see Table 1).

**Table 1: Summary of the Disallowed Costs and Funds to Be Put to Better Use (For the Year Ended September 30, 2011)**

| Category | Disallowed Costs | | Funds to be Put to Better Use | |
|---|---|---|---|---|
| | Number of Reports | Dollars | Number of Reports | Dollars |
| 1. Reports pending final management action at the beginning of the reporting period | 0 | $0 | 0 | $0 |
| 2. Plus: Reports pending management decisions during the reporting period | 4 | $7,516,615 | 3 | $107,100,000 |
| 3. Total reports pending final action during the reporting period (1+2) | 4 | $7,516,615 | 3 | $107,100,000 |
| 4. Reports on which final action was taken during the reporting period | 1 | $372,557 | 1 | $1,858,059 |
| 5. Audit reports pending final action at the end of the reporting period | 3 | $4,816,615 | 2 | $93,800,000 |

## 2. Prior-Year OIG Reports Pending Completion of Final Management Action

As of September 30, 2011, there were 15 OIG audit reports issued in prior fiscal years containing a total of 33 recommendations on which a final management decision had been made, but final management action was still pending (see Table 2).

The nature of the final management action associated with the 33 open and outstanding audit recommendations can be broken down into three broad categories, namely: (1) Internal Monitoring/Program Review for Compliance; (2) Development/Revision of Policy, and; (3) System Enhancements/Updates.

By way of comparison, for the fiscal year ended September 30, 2010, there were 12 OIG audit reports containing 34 recommendations on which final management decisions were made in prior years, but final management action was still pending. For the five year period ended September 30, 2011, the number of OIG audit recommendations pending final management action one year or more after issuance of a final audit report ranged between 33 and 52.

1. NASA's Grant Administration and Management (IG-11-026).

2. Ibid.

| Table 2: Summary of OIG Audit Reports Pending Final Management One Year or More After Issuance of a Final Report (As of September 30, 2011) | | | | |
|---|---|---|---|---|
| **Report Number** | | **No. of Recommendations** | | |
| **Report Date** | **Report Title** | **Open** | **Closed** | **Total** |
| IG-05-016 (5/12/2005) | NASA's Vulnerability Assessment Program | 1 | 3 | 4 |
| IG-07-014 (6/19/2007) | Controls Over the Detection, Response and Reporting of Network Security Incidents Needed Improvement at 4 NASA Centers Reviewed | 1 | 7 | 8 |
| IG-08-025 (9/19/2008) | Kennedy Space Center's Security Program Needed Improvement | 4 | 4 | 8 |
| IG-09-003 (11/13/2008) | Review of NASA Stolen Property at GSFC and MSFC | 1 | 4 | 5 |
| IG-09-015 (4/27/2009) | NASA's Process for Providing Personal Identity Verification (PIV) Cards Were Not Completely Effective in Meeting Federal Requirements | 2 | 4 | 6 |
| IG-09-017 (7/28/2009) | Review of the Space Flight Awareness Honoree Launch Conference Event | 1 | 0 | 1 |
| IG-10-011 (3/29/2010) | Final Report on the Review of the Constellation Program's Request to Discontinue Using the Metric System of Measurement | 2 | 1 | 3 |
| IG-10-013 (5/13/2010) | Review of the Information Technology Security of the Internet Protocol Operational Network (IONet) | 2 | 0 | 2 |
| IG-10-015 (6/18/2010) | Review of NASA's Microgravity Flight Services | 1 | 2 | 3 |
| IG-10-016 (7/6/2010) | NASA's Astronaut Corps: Status of Corrective Actions Related to Health Care Activities | 1 | 1 | 2 |
| IG-10-018 (8/5/2010) | Audit of Cybersecurity Oversight of NASA's Enterprise Document Management System | 10 | 5 | 15 |
| IG-10-021 (8/23/2010) | Review of the Fleet Management Program at the Jet Propulsion Laboratory | 1 | 2 | 3 |
| IG-10-019 (9/14/2010) | Information Technology Security: Improvements Needed in NASA's Continuous Monitoring Processes | 2 | 0 | 2 |
| IG-10-024 (9/16/2010) | Review of NASA's Management and Oversight of Its Information Technology Security Program | 3 | 0 | 3 |
| IG-10-023 (9/21/2010) | Review of NASA's Tracking and Data Relay Satellite System | 1 | 3 | 4 |
| **15** | **Totals** | **33** | **36** | **69** |

## 3. Final Management Decisions Not Made Within Six Months of a Report Date

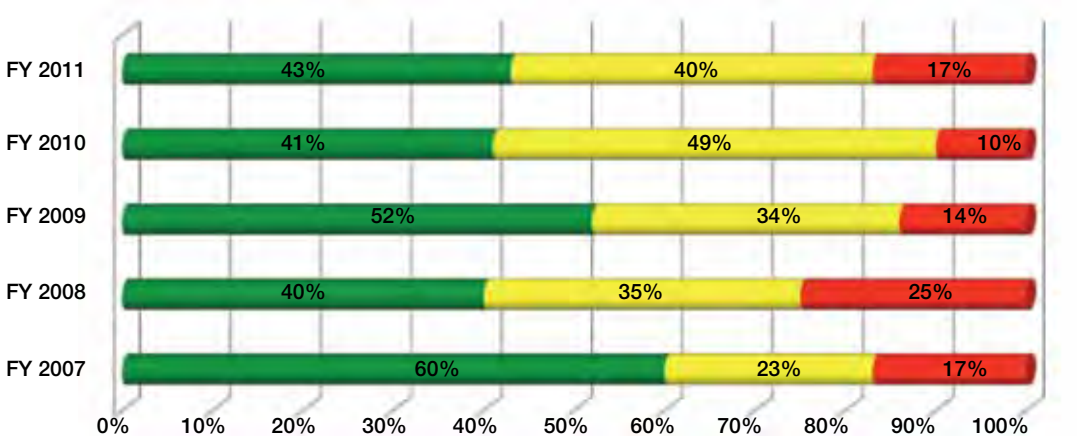
During FY 2011, the OIG issued 27 reports containing 102 recommendations addressed to NASA which required a final management decision within six months of the respective final report dates. For the fiscal year ended September 30, 2011, NASA reported no outstanding final management decisions pending more than six months after the issuance of a final OIG audit report. For comparative purposes, for the fiscal year ended September 30, 2010, NASA reported no outstanding final management decisions pending more than six months after the issuance of a final OIG audit report. Furthermore, for the five-year period ended September 30, 2011, no final management decision on any OIG audit recommendation was made more than six months after issuance of a final OIG audit report.

## 4. Audit Recommendation Closure Efficiency

During FY 2011, 72 OIG-issued audit recommendations, including 41 recommendations issued in prior fiscal years, were closed based on responsive final management action. Of the 72 recommendations closed in FY 2011, 43 percent (31) were closed within one year of the issuance of the associated audit report, while 83 percent (60) were closed within two years of the issuance of the associated audit report.

In FY 2010, 41 percent (31) of OIG audit recommendations were closed with one year of the issuance of the associated audit report, and ninety percent (68) were closed within two years of the issuance of the associated audit report. For the five year period ended September 30, 2011, an average of 47 percent of OIG-issued audit recommendations were closed within one year of the final issuance of the associated audit report, while an average of 83 percent of OIG-issued audit recommendations were closed within two years of the issuance of the associated audit report (see Table 3).

**Table 3: Closure Efficiency: OIG Recommendations**
**Fiscal Years 2007-2011**
(As of September 30, 2011)




| | FY 2007 | FY 2008 | FY 2009 | FY 2010 | FY 2011 |
|---|---|---|---|---|---|
| Closed < 1 year after report | 60% | 40% | 52% | 41% | 43% |
| Closed > 1 < 2 years after report | 23% | 35% | 34% | 49% | 40% |
| Closed > 2 years after report | 17% | 25% | 14% | 10% | 17% |

As previously noted, NASA's completion of corrective action in response to OIG audit recommendations is contingent upon a variety of factors including the complexity of the planned corrective actions and available resources. Despite these constraints, NASA management is committed to the improvement of Agency activities as identified by the OIG in their audit reports and associated recommendations.

# Improper Payments Information Act (IPIA) Assessment

The National Aeronautics and Space Administration (NASA) is dedicated to reducing fraud, waste, and abuse by adequately reviewing and reporting programs susceptible to improper payments in accordance with the Office of Management and Budget (OMB) Circular A-123 Management's Responsibility for Internal Control, Appendix C, Requirements for Effective Measurement and Remediation of Improper Payments. To improve the integrity of the Federal government's payments and the efficiency of its programs and activities, Congress enacted the Improper Payments Information Act (IPIA) of 2002 (Public Law 107-300). The IPIA contains requirements in the areas of improper payment identification and reporting. It requires agency heads to annually review all programs and activities, identify those that may be susceptible to significant improper payments, estimate annual improper payments in susceptible programs and activities, and report the results of their improper payment activities.

On July 22, 2010, the President signed into law the Improper Payments Elimination and Recovery Act (IPERA; P.L. 111-204). IPERA amended the IPIA and generally repealed the Recovery Auditing Act (Section 831, Defense Authorization Act, for FY 2002; P.L. 107-107). Subsequently, OMB issued Memorandum M-11-16 modifying Circular A-123 Appendix C, Part I and Part II (which was issued in August 2006 as OMB Memorandum M-06-23). OMB Memorandum M-11-16 requires each Executive branch agency to:

- Review all of its programs and activities to identify those susceptible to significant improper payments. OMB defines significant improper payments as gross annual improper payments (i.e., the total amount of overpayments plus underpayments) in the program exceeding (1) both 2.5 percent of program outlays and $10,000,000 of all program or activity payments made during the fiscal year reported or (2) $100,000,000 (regardless of the improper payment percentage of total program outlays).
- Obtain a statistically valid estimate of the annual amount of improper payments in programs and activities for those programs that are identified as susceptible to significant improper payments.
- Implement a plan to reduce improper payments.
- Report estimates of the annual amount of improper payments in programs and activities and progress in reducing them.

The IPIA defines an improper payment as any payment that should not have been made or that was made in an incorrect amount (including overpayments and underpayments) under statutory, contractual, administrative, or other legally applicable requirements. It includes any payment to an ineligible recipient, any payment for an ineligible service, any duplicate payment, payments for services not received, and any payment that does not account for credit for applicable discounts. Moreover, when an agency's review is unable to discern whether a payment is proper as a result of insufficient or lack of documentation, this payment must also be considered an improper payment.

Throughout the past five years, NASA has diligently met IPIA program compliance by launching OMB-compliant risk assessments, updating NASA payment process documentation, selecting OMB-compliant statistical samples for testing, drafting comprehensive test procedures, reporting results in the annual PAR and documenting the IPIA review process and results in comprehensive work papers.

During FY 2011, NASA continued its efforts to improve the integrity of its payments and the efficiency of its programs by updating the annual risk assessment. The updated risk assessment identified 34 programs in scope and covered $19.1 billion in FY 2010 disbursements. Once the programs were evaluated, NASA identified the following seven programs for review to determine their susceptibility to improper payments:

- Constellation Systems
- Institutions and Management
- International Space Station (ISS)
- Mars Exploration
- Reimbursable – Science Mission Directorate Programmatic (RMB-SCMD)
- Space Communications and Navigation (SCaN)
- Space Shuttle Program

Total payments related to these programs amounted to approximately $5.1 billion in FY 2010. As in previous years, with the assistance of contractor support, NASA performed an improper payment review of each program in accordance with Appendix C of OMB Circular A-123 and identified an estimated total of $1,510,548 in improper payments with an estimated improper payment percentage of 0.02959%. This annual estimate was based on NASA's FY 2010 disbursements (October 1, 2009 to September 30, 2010). Although the testing performed found that the programs did not have significant improper payments, as defined by OMB A-123, Appendix C, NASA will continue to monitor payments and take appropriate corrective action for any identified improper payments.

# Improper Payments Information Act Reporting Details

To conduct the FY 2011 IPIA assessment, NASA adhered to the established improper payment methodology, considered lessons learned from past IPIA assessments, and the NASA Risk Assessment methodology. In order to satisfy the IPIA requirements the following tasks and activities were executed:

- Updated the FY 2010 risk assessment;
- Selected a statically valid sample of payments;
- Conducted a test of all transactions selected in the sample and extrapolated the results to make a valid estimate; and,
- Reported on the details of testing and findings (if any) of the program

In the following section we summarize the details of the FY 2011 IPIA program.

## I. Risk Assessment

NASA's risk assessment methodology was developed using criteria established for determining levels of risk and evaluating all major programs against these criteria. Risk factors included conditions related to financial processing and internal controls, internal and external monitoring and assessments, human capital risk, programmatic risk, and the nature of programs and payments.

In FY 2011, NASA performed a comprehensive qualitative and quantitative risk assessment to identify programs susceptible to high risk of significant improper payments. NASA's risk assessment methodology is illustrated in Table 1 below, along with a brief summary of steps and results.

**Table 1: NASA's Risk Assessment Methodology and Results**

| Determine Scope | Identify Programs Eligible for Assessment | Analyze Risk Conditions | Prepare Risk Assessment |
|---|---|---|---|
| • Identified 99 distinct programs<br>• Estimated maximum error rate of program disbursements at 12.5%<br>• Materiality level of programs in-scope set at >$80M<br>• The programs in scope covered $19.1 billion in FY 2010 disbursements | • Identified 34 programs within assessment scope<br>• Identified 8 programs that received ARRA funds<br>• Non-programmatic disbursements such as Institutions & Management also included | • Evaluated FY 2010 Audit Reports, Findings and Recommendations<br>• Evaluated Financial Management trends in Internal Control<br>• Evaluated risk conditions including control environment, human capital risk and nature of payments. | • Updated information based on intelligence gathered from NASA Financial Management Products and independent reviews<br>• Populated Risk Assessment matrix with initial feedback<br>• Identified 9 programs susceptible to improper payments based on risk ratings |

## (1) Determine Scope

To determine the scope of programs subject to the Risk Assessment, NASA prepared an initial selection based on the FY 2010 total disbursements; identifying 99 distinct programs. NASA generated and provided the disbursement totals for each program from its financial management system. The aggregate disbursement total was validated against NASA's SF-133, Report on Budget Execution and Budgetary Resources.

## (2) Identify Programs Eligible for FY 2011 Assessment

A review of the 99 distinct programs was made to determine whether or not they meet the materiality thresholds for review. The materiality of disbursements is derived from an estimated error rate of 12.5 percent of program disbursements. Using this estimate, the materiality level of programs in scope was set at greater than $80 million. The number of programs in scope was reduced to 34 based on the materiality of disbursements. NASA also developed a questionnaire of additional risk conditions that NASA's programs were evaluated against. The questionnaires were completed by Senior Management and selected Program personnel and captured data such as risk assessment scores, disbursement values, and estimated error rates.

## (3) Analyze Risk Condition

The control environment, internal and external monitoring, human capital risk, programmatic risk, and nature of program payment risk factors were analyzed during the risk assessment. NASA also reviewed documents, including the Review of Open Audit Recommendations Affecting Recovery Act Activities (Report Number. IG-10-014: Assignment No. A-09-009-01) and the Government Accountability Office (GAO) report Improper Payments: Weaknesses in USAID's [U.S. Agency for International Development's] and NASA's Implementation of the Improper Payments Information Act and Recovery Auditing (GAO-08-77, November 9, 2007). Among other documents, NASA also examined the report on NASA's Overall Assessment of Internal Control over Financial Reporting. Once this review and analysis was complete, the FY 2011 Risk Assessment was updated to reflect the NASA programs found susceptible to improper payments.

## (4) Prepare Risk Assessment

The programs identified during FY 2011 are: Constellation Systems, Earth Science Research, Earth Systematic Missions, Institutions and Management, ISS, Mars Exploration, RMB-SCMD Programmatic, SCaN and Space Shuttle. Table 2 below provides the FY 2011 programs susceptible to improper payments. A score greater than 3.00 is deemed "high risk" per the NASA Risk Assessment Methodology.

**Table 2: NASA Programs Identified as Susceptible to Improper Payments**

| Program | Determined Risk After Testing in FY 2008 | Determined Risk After Testing in FY 2009 | Determined Risk After Testing in FY 2010 | FY 2011 Risk Assessment Rating | Selected for Testing FY 2011 |
|---|---|---|---|---|---|
| Constellation Systems | N/A | Low | Low | 3.80 | Yes |
| Earth Science Research | N/A | Low | Low | 3.58 | No |
| Earth Systematic Missions | Low | Low | Low | 3.32 | No |
| Institutions and Management | Low | Low | Low | 3.50 | Yes |
| International Space Station (ISS) | Low | Low | Low | 3.20 | Yes |
| Mars Exploration | Low | Low | Low | 3.48 | Yes |
| RMB-SCMD Programmatic | N/A | N/A | Low | 3.52 | Yes |
| SCaN | N/A | N/A | Low | 3.10 | Yes |
| Space Shuttle | Low | Low | Low | 3.50 | Yes |

As shown in Table 2, based on testing results from previous years (FY 2008 to FY 2010), some programs initially identified during the risk assessment (any programs with a risk assessment rating of greater than 3.0) were deemed low risk and testing was not required during FY 2011. The following programs that received high risk ratings in FY 2011 but were tested in prior years and were deemed to be low risk and do not require testing again in FY 2011 are:

- Earth Science Research (1)
- Earth Systematic Missions (1)

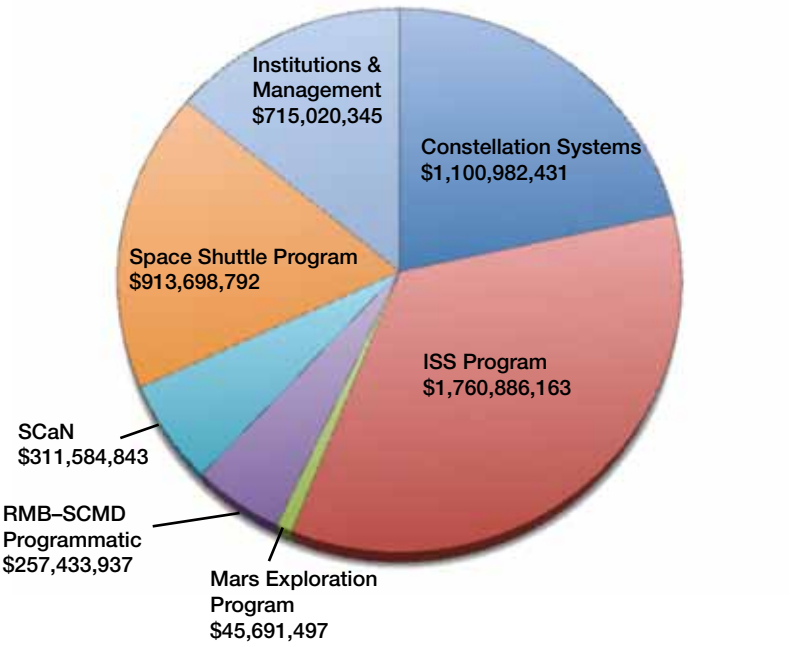
Therefore, the following programs were selected for testing in FY 2011:

- Constellation Systems
- Institutions and Management
- ISS
- Mars Exploration
- RMB-SCMD
- SCaN
- Space Shuttle

## II. Statistical Sampling

For each program selected for testing, NASA developed a statistically valid random sample of program payments, in accordance with OMB guidelines. NASA constructed a stratified, random sample to yield an estimate with a 90 percent confidence level with a margin of error of plus or minus 2.5 percent for each program. The sample was drawn from the universe of disbursements that occurred from October 1, 2009, through September 30, 2010. For each selected program undergoing an improper payment review, NASA developed samples for the following payment types: vendor payments; government purchase card transactions; and travel expenditures. A total number of 1,788 transactions were selected. Figure 1 below illustrates the total payments for each program selected for testing in FY 2011.

**Figure 1: Total Outlays for Programs Susceptible to a High Risk of Improper Payments**



A random sample was selected for each of the seven programs identified as susceptible to high risk of significant improper payments.

**Table 3: Population and Sample Amounts by Program**

| Program | Contracts | | Travel | | Purchase Cards | | Totals | |
|---|---|---|---|---|---|---|---|---|
| | Population | Sample | Population | Sample | Population | Sample | Population | Sample |
| Constellation Systems | | | | | | | | |
| Transactions | 32,120 | 312 | 33,399 | 5 | 19,055 | 3 | 84,574 | 320 |
| Dollar Amount | $1,081,754,115 | $437,470,134 | $13,541,975 | $5,525 | $5,686,341 | $27,312 | $1,100,982,431 | $437,502,971 |
| Institutions and Management | | | | | | | | |
| Transactions | 20,622 | 307 | 3,144 | 1 | 24,561 | 8 | 48,327 | 316 |
| Dollar Amount | 698,800,772 | 323,849,019 | 1,389,701 | 490 | 14,829,872 | 31,857 | 715,020,345 | 323,881,366 |
| ISS Program | | | | | | | | |
| Transactions | 15,296 | 364 | 13,519 | 1 | 8,113 | 1 | 36,928 | 366 |
| Dollar Amount | 1,752,838,532 | 1,229,570,808 | 6,318,982 | 8,421 | 1,728,649 | (224) | 1,760,886,163 | 1,229,579,005 |
| Mars Exploration | | | | | | | | |
| Transactions | 1,945 | 146 | 1,377 | 6 | 2,322 | 5 | 5,644 | 157 |
| Dollar Amount | 44,637,583 | 31,463,637 | 576,576 | 5,734 | 477,338 | 5,875 | 45,691,497 | 31,475,246 |
| RMB–SCMD Programmatic | | | | | | | | |
| Transactions | 3,342 | 136 | 4,187 | 2 | 4,128 | 1 | 11,657 | 139 |
| Dollar Amount | 254,610,680 | 183,198,701 | 1,886,651 | 6,803 | 936,606 | 435 | 257,433,937 | 183,205,939 |
| SCaN | | | | | | | | |
| Transactions | 6,035 | 206 | 4,484 | 3 | 3,824 | 2 | 14,343 | 211 |
| Dollar Amount | 308,529,868 | 174,634,892 | 1,858,798 | 3,391 | 1,196,177 | 4,490 | 311,584,843 | 174,642,773 |
| Space Shuttle Program | | | | | | | | |
| Transactions | 15,926 | 276 | 17,378 | 2 | 9,636 | 1 | 42,940 | 279 |
| Dollar Amount | 904,365,407 | 563,638,842 | 7,102,153 | 7,150 | 2,231,232 | 1,099 | 913,698,792 | 563,647,091 |
| | | | | | | | | |
| Total | | | | | | | | |
| Transactions | 95,286 | 1,747 | 77,488 | 20 | 71,639 | 21 | 244,413 | 1,788 |
| Dollar Amount | $5,045,536,957 | $2,943,826,033 | $32,674,836 | $37,514 | $27,086,215 | $70,844 | $5,105,298,008 | $2,943,934,391 |

## III. Conclusion

In total, NASA identified one (1) improper vendor payment as identified in Table 4 below:

**Table 4: Improper Payments by NASA Program**

| Finding—Discount Not Taken | | |
|---|---|---|
| Program | Improper Payment Amount Over (Under) | # of Payments |
| Constellation Systems | $2,343.87 | 1 |
| **Total** | **$2,343.87** | **1** |

As illustrated below, an extrapolation of the one payment over the entire universe resulted in $1,510,548 of estimated improper payments with an estimate percentage of 0.02959% during the period October 1, 2009, through September 30, 2010. Both the improper payment percentage and the estimated amount of improper payments are not considered significant as defined by OMB A-123, Appendix C. Consequently, NASA is not required to submit a written corrective action plan; however, NASA will consider opportunities for enhancement in FY 2012 to further reduce its exposure to improper payments. Table 5 below shows the total payments by population, sample amount, and annual estimate of improper payments by program.

**Table 5: Total Payments by Population, Sample Amount and Annual Estimate of Improper Payments by Program**

| Program | Transactions | | Dollars | | FY 2011 % Estimate of Improper Payments | FY 2011 $ Estimate of Improper Payments |
|---|---|---|---|---|---|---|
| | Population | Sample | Population | Sample | | |
| Constellation Systems | 84,574 | 320 | $1,100,982,431 | $437,502,971 | 0.13719% | $1,510,548 |
| Institutions and Management | 48,327 | 316 | 715,020,345 | 323,881,366 | 0.00000% | $0 |
| ISS | 36,928 | 366 | 1,760,886,163 | 1,229,579,005 | 0.00000% | $0 |
| Mars Exploration | 5.644 | 157 | 45,691,497 | 31,475,246 | 0.00000% | $0 |
| RMB–SCMD Programmatic | 11,657 | 139 | 257,433,937 | 183,205,939 | 0.00000% | $0 |
| SCaN | 14,343 | 211 | 311,584,843 | 174,642,773 | 0.00000% | $0 |
| Space Shuttle | 42,940 | 279 | 913,698,792 | 563,647,091 | 0.00000% | $0 |
| **Total** | **244,413** | **1,788** | **$5,105,298,008** | **$2,943,934,391** | **0.02959%** | **$1,510,548** |

**Table 6: Improper Payment Reduction Outlook (In Millions of Dollars)**

| Program | 2009 Disburse-ments | 2009 IP% | 2009 IP$ | 2010 Disburse-ments | 2010 IP% | 2010 IP$ | 2011 Disburse-ments | *2011 IP% | 2011 IP$ | **2012 Est. Outlays | *2012 IP% | 2012 IP$ | **2013 Est. Outlays | *2013 IP% | 2013 IP$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Constel-lation Systems | $3,108 | 0.00% | $0 | $3,367 | 0.14% | $1.5 | $43 | 0.14% | $0.6 | $43 | 0.14% | $0.6 | $43 | 0.14% | $0.6 |

*Assumes 2011 Improper payment rate remains constant in the out years.

**Assumes projected outlays remain constant in the out years.

# Recapture Audit

On July 22, 2010, the President signed into law the Improper Payments Elimination and Recovery Act (IPERA; Pub. L. No.111-204). IPERA requires all Federal agencies to conduct payment recapture audits. NASA continues to perform recapture audits as part of its overall program to ensure effective internal control over payments for each program and activity that expends $1 million or more annually if conducting such audits would be cost-effective. In FY 2011 NASA performed a recapture audit focused on its FY 2009 disbursements.

In accordance with the amended Office of Management and Budget (OMB) Circular A-123, Appendix C guidance, agencies may determine to exclude classes of contracts and contract payments from recapture audit activities if the agency determines that the recapture audits are inappropriate or not a cost-effective method for identifying and recovering improper payments. NASA employs the Defense Contract Audit Agency (DCAA), at significant expense, to perform auditing procedures on cost-type contracts. Performing a separate recapture audit on these cost-type contracts would be duplicative and not cost-effective. In addition, the contractual terms of NASA's cost-type contracts provides for audit access only by the DCAA. Increasing audit access would require contract modifications for existing contracts, which would likely result in increased costs. Consequently, NASA does not consider it cost-effective to conduct payment recapture audits for cost-type contracts. Consequently, NASA does not include cost-type contracts in its assessment for recapture audits.

NASA engages an industry-leading contracting firm to perform recapture auditing under a contingency contract. This year, FY 2009 disbursements were audited and the results are listed in the table on the following page. The firm audited FY 2006 through FY 2008 disbursements in prior years. The recapture audit of FY 2010 disbursements is underway.

## Summary of Recapture Audit Activity (Amounts in Dollars)

| Program or Activity | Type of Payment | Amount Subject to Review for Reporting FY 2009 | Actual Amount Reviewed and Reported FY 2009 | Amounts Identified for Recovery FY 2009 | Amount Recovered FY 2009 | % of Amount Recovered Out of Amount Identified FY 2009 | Amount Outstanding FY 2009 | % of Amount Outstanding Out of Amount Identified FY 2009 | Amount Determined Not to Be Collectable FY 2009 | % of Amount Determined Not to be Collectable out of Amount Identified FY 2009 | Amounts Identified for Recovery (2008 + PYs) | Amounts Recovered (2008 + PYs) | Cumulative Amounts Identified for Recovery (2009 + PYs) | Cumulative Amounts Recovered (2009 + PYs) | Cumulative Amounts Outstanding (2009 + PYs) | Cumulative Amounts Determined Not to Be Collectable (2009 + PYs) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NASA | Contract | $4,378,854,849 | $4,378,854,849 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $234,376 | $216,009 | $234,376 | $216,009 | $18,367 | $18,367 |

## Payment Recapture Audit Targets

| Type of Payment | CY Amount Identified | CY Amount Recovered | CY Recovery Rate | CY + 1 Recovery Rate Target | CY + 2 Recovery Rate Target | CY + 3 Recovery Rate Target |
|---|---|---|---|---|---|---|
| Contracts | $0 | $0 | N/A | N/A | N/A | N/A |

## Aging of Outstanding Overpayments

| Type of Payment | CY Amount Outstanding (0-6 Months) | CY Amount Outstanding (6 Months to 1 Year) | CY Amount Outstanding (Over 1 Year) |
|---|---|---|---|
| Contracts | $0 | $0 | $0 |

## Disposition of Recaptured Funds

| Type of Payment | Agency Expenses to Administer the Program | Payment Recapture Auditor Fees | Financial Management Improvement Activities | Original Purpose | Office of Inspector General | Returned to Treasury |
|---|---|---|---|---|---|---|
| Contracts | $0 | $0 | N/A | N/A | N/A | $0 |

## Overpayments Recaptured Outside of Payment Recapture Audits

| Source of Recovery | Amount Identified | Amount Recovered (CY) | Amount Identified (PY) | Amount Recovered (PY) | Cumulative Amount Identified (CY + PYs) | Cumulative Amount Recovered (CY + PYs) |
|---|---|---|---|---|---|---|
| N/A | $0 | $0 | $0 | $0 | $0 | $0 |

NASA has taken steps through Improper Payment reviews and recapture audits to continue holding Agency managers accountable for reducing and recovering improper payments. The recapture audit process is monitored by headquarters to ensure compliance with NASA's Recovery Audit Guidance. In addition, all collection and disbursement functions are centralized which ensures prompt and recovery of overpayments, which helps to control and review contract payments.

NASA has the infrastructure and information technology in place to reduce improper payments. There are no statutory or regulatory barriers limiting NASA's ability to reduce improper payments.

# Summary of Financial Statement Audit and Management Assurances

The following tables summarize the Agency's FY 2011 Financial Statement Audit and Management Assurances. Table 1 summarizes the status of prior year—FY 2010 material weaknesses identified, if any by the Financial Statement Auditor. Table 2 summarizes the status of prior year material weaknesses, if any identified by NASA Management.

### Table 1: Summary of Financial Statement Audit

| | | | | | |
|---|---|---|---|---|---|
| **Audit Opinion** | Unqualified | | | | |
| **Restatement** | No | | | | |
| | | | | | |
| **Material Weaknesses** | **Beginning Balance** | **New** | **Resolved** | **Consolidated** | **Ending Balance** |
| None | 0 | 0 | 0 | 0 | 0 |
| **Total Material Weaknesses** | **0** | **0** | **0** | **0** | **0** |

### Table 2: Summary of Management Assurance

| **Effectiveness of Internal Control Over Financial Reporting (FMFIA 2)** | | | | | | |
|---|---|---|---|---|---|---|
| Statement of Assurance | Unqualified | | | | | |
| **Material Weaknesses** | **Beginning Balance** | **New** | **Resolved** | **Consolidated** | **Reassessed** | **Ending Balance** |
| None | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Material Weaknesses** | **0** | **0** | **0** | **0** | **0** | **0** |
| | | | | | | |
| **Effectiveness of Internal Control Over Operations (FMFIA 2)** | | | | | | |
| Statement of Assurance | Unqualified | | | | | |
| **Material Weaknesses** | **Beginning Balance** | **New** | **Resolved** | **Consolidated** | **Reassessed** | **Ending Balance** |
| None | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Material Weaknesses** | **0** | **0** | **0** | **0** | **0** | **0** |
| | | | | | | |
| **Conformance With Financial Management System Requirements (FMFIA 4)** | | | | | | |
| Statement of Assurance | Systems Conform. | | | | | |
| **Non-Conformances** | **Beginning Balance** | **New** | **Resolved** | **Consolidated** | **Reassessed** | **Ending Balance** |
| **Total non-conformances** | **0** | **0** | **0** | **0** | **0** | **0** |
| | | | | | | |
| **Compliance With Federal Financial Management Improvement Act (FFMIA)** | | | | | | |
| | Agency | | | Auditor | | |
| Overall Substantial Compliance | Yes | | | Yes | | |
| 1. System Requirements met? | Yes | | | | | |
| 2. Accounting Standards met? | Yes | | | | | |
| 3. USSGL at Transaction Level met? | Yes | | | | | |

# NASA FY 2011 Public Law 111-117 Undisbursed Balances in Expired Grant Accounts

NASA monitors and tracks grants undisbursed balances in expired accounts through a monthly review of internal control activities designed to identify undisbursed balances in expired accounts. The Continuous Monitoring Program (CMP) ensures ongoing review and validation of financial data and the effectiveness of internal controls over the entire financial management process, including grants. When grants undisbursed balances in expired accounts are identified, appropriate action is taken to ensure optimum use of grant resources.

NASA generates financial management reports to aid in the tracking and monitoring of undisbursed amounts. An aging report of open obligations is generated on a monthly basis to determine the last day activity occurred. For open obligations in which no activity has occurred in a six month period and/or there is no supporting documentation, further review is performed to determine the validity of obligation balances and the existence of valid source documentation. Additionally, further analysis is performed to determine if funds can be de-obligated. If obligations are valid, the aging reports are updated to reflect that obligations have been confirmed with procurement as valid.

NASA will continue to track undisbursed balances in expired grant accounts through its monthly review of internal control activities designed to identify funds for de-obligation. This involves the continuous monitoring of undisbursed balances, identifying balances that should be de-obligated, and performing timely close-out of grants and other activities. Additionally, NASA's financial management and procurement offices will continue to collaborate in monitoring and tracking undisbursed balances.

Currently, NASA does not have undisbursed balances in expired accounts that may be returned to the Treasury of the United States. The following chart reflects the total number and dollar amount of undisbursed grants in expired appropriations. All amounts have been obligated to a specific project.

| Year | Total Number of Expired Grants | Total Amount of Expired Grants (In Millions of Dollars) |
|---|---|---|
| 2008 | 1,457 | $41 |
| 2009 | 1,657 | $18 |
| 2010 | 800 | $10 |

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