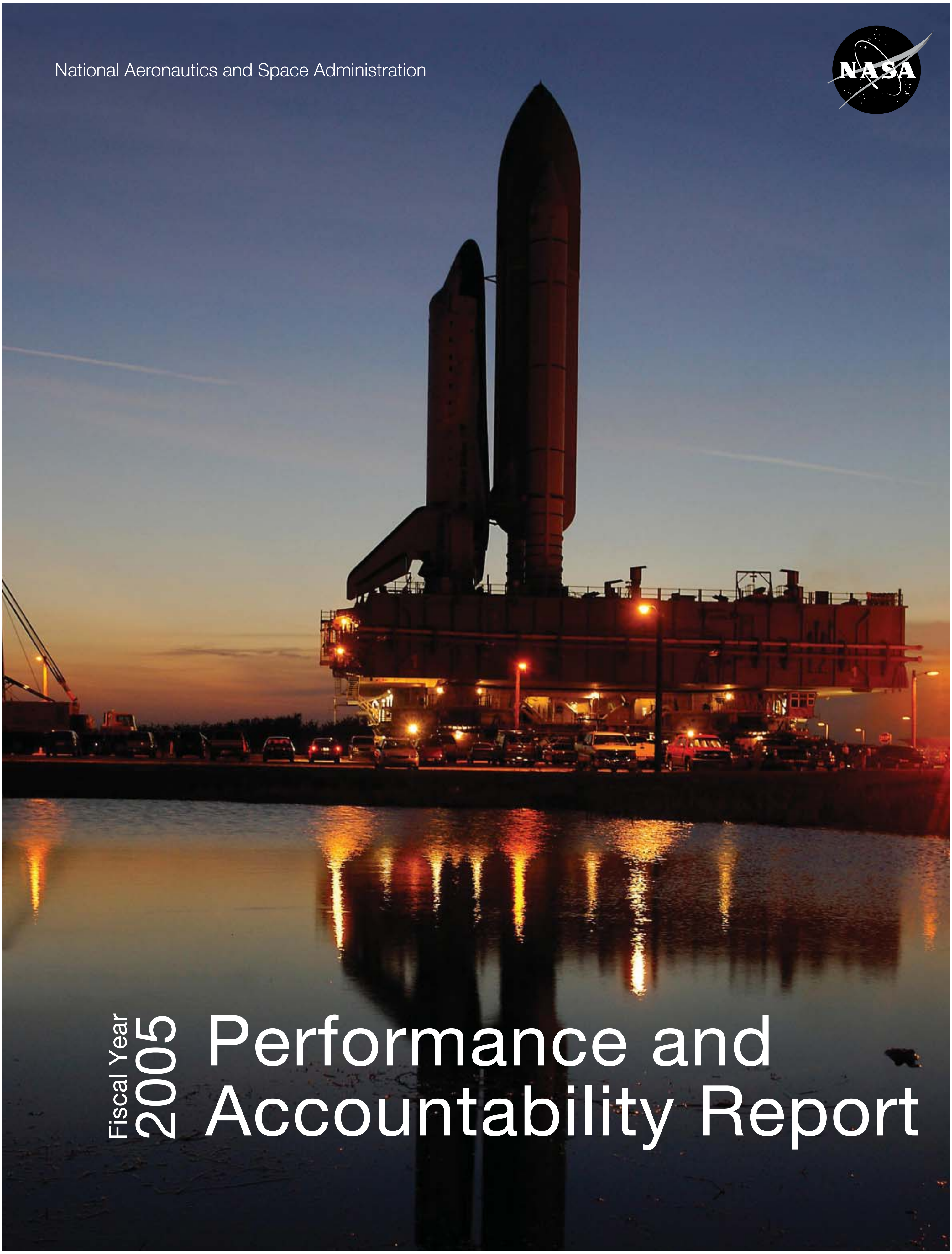
National Aeronautics and Space Administration



Fiscal Year 2005

Performance and Accountability Report

Introduction to NASA's Performance and Accountability Report

This is the National Aeronautics and Space Administration's (NASA) Fiscal Year 2005 (FY 2005) Performance and Accountability Report. It is a detailed account of NASA's performance in achieving the Agency's annual goals and long-term objectives for its programs, management, and budget. This report includes detailed performance information and financial statements as well as management challenges and NASA's plans and efforts to overcome them.

NASA's FY 2005 Performance and Accountability Report was created to meet various U.S. Government reporting requirements (including the Government Performance and Results Act, the Chief Financial Officers Act of 1990, and the Federal Financial Management Improvement Act of 1996). However, it also presents the Agency with an opportunity to tell the American people how NASA is doing. This introduction is intended to familiarize the reader with the types of information contained in this report and where that information is located.

NASA's Performance and Accountability Report is divided into three major sections:

Part 1—Management Discussion & Analysis. Part 1 presents a snapshot of NASA's FY 2005 performance achievements. Part 1 also addresses financial and management activities, including NASA's response to challenges and high-risk areas identified by NASA and outside organizations, and the Agency's progress on implementing the six initiatives of the President's Management Agenda.

Part 2—Detailed Performance Data. Part 2 provides detailed information on NASA's progress toward achieving specific milestones and goals as defined in the Agency's FY 2005 Performance Plan Update. Part 2 also describes the actions that NASA will take in the future to achieve goals that the Agency did not meet in FY 2005.

Part 3—Financials. Part 3 includes NASA's financial statements and an audit of these statements by independent auditors, in accordance with government auditing standards.

Appendices. The Appendices include a list of Office of Management and Budget Program Assessment Rating Tool (PART) Recommendations, the Office of Inspector General Summary of Serious Management Challenges and audit follow up reports required by the Inspector General Act.

Cover: Discovery lingers at the foot of launch pad 39B in the evening twilight on April 6, 2005, during its first roll out. (Photo: S. Andrews/NASA)

Table of Contents

APPENDICES 217

Part 1: Management Discussion & Analysis

Previous page: Shuttle *Discovery* gets a piggyback ride from NASA's Boeing 747 from Edwards Air Force Base in California, where STS-114 landed on August 9, 2005, to Kennedy Space Center in Florida. The cross-country trip took two days and included several stops for refueling. The 747, a commercial jet modified to hold the extra weight of a Shuttle, serves as a ferry between landing sites and the launch complex at Kennedy. The Shuttle is placed atop the jet by a gantry-like structure that hoists the Shuttle off the ground high enough to drive the jet underneath. (Photo: C. Thomas/NASA)

Above: NASA's two highly-modified F-15 research jets go through their paces over NASA Dryden Flight Research Center during a mission in late July 2005 that supported the Intelligent Flight Control System project. The F-15B 837 (bottom), which was flying validation flights for the project, is refueled by a KC-135 tanker. The pilot of the F-15B 836 (top) flew safety chase for the other jet and practiced aerial refueling.

The Intelligent Flight Control System project seeks to incorporate self-learning neural network concepts into flight control software to enable a pilot to maintain control and safely land an aircraft that has suffered a major systems failure or combat damage. The adaptive neural network software "learns" the new flight characteristics, onboard and in real time, thereby helping the pilot to maintain or regain control and prevent a potentially catastrophic aircraft accident. NASA's F-15B 837 is equipped with the test software and is modified from a standard F-15 configuration. The flight in the picture was part of a test leading to the start of Generation II flights planned for later in 2005. (Photo: C. Thomas/NASA)

Message from the Administrator

Nearly two years ago, President George W. Bush committed the Nation to a new direction in space that set forth a fresh, clear mission for NASA. Throughout FY 2005, NASA enthusiastically worked to advance the Vision for Space Exploration, an ambitious plan for human and robotic space exploration that will advance America's economic, scientific and security interests. This year, we achieved the Vision's first goal—returning the Space Shuttle to flight. Next, we will complete the International Space Station and return humans to the Moon in preparation for subsequent voyages to Mars and beyond.

WHY EXPLORE SPACE?

The spirit of exploration is embedded in our human DNA. Humans explore, and space exploration is the frontier of our time.

We see plainly from the evidence of history that those nations that have made a sustained commitment to exploration have prospered in the long run. In the process of exploring space, we develop new technologies and capabilities with the potential to benefit billions of people here on Earth. Spaceflight also provides unprecedented opportunities for the United States to lead peaceful and productive international relationships in the world community.

Over the past 12 months, NASA has made significant strides in advancing the Vision for Space Exploration, putting the Agency in a better position to address the challenges ahead.

LOOKING FORWARD

Even as we are returning the Space Shuttle to flight, we are making plans for its retirement by 2010, because America requires a new generation of spacecraft to meet our challenging new exploration goals. We will utilize the Shuttle fleet in a disciplined, measured fashion over the next five years to complete assembly of the International Space Station. If feasible, we also will conduct a mission to service the Hubble Space Telescope.

NASA will use, to the fullest extent possible, commercially developed cargo resupply and crew rotation capabilities for the Station. This approach is a key component of the Vision: generating competition in the private sector that will result in savings that can be applied elsewhere in the program, and promoting further commercial opportunities in the aerospace industry.

After completing the Space Station, we will focus on the challenge of exploration beyond low Earth orbit. The basic element of our exploration architecture is, of course, the launch system. This new generation of spacecraft will be based on proven designs and technologies from the Apollo and Space Shuttle programs while having far greater capabilities to carry larger and heavier cargos into space for longer duration exploration missions.

Finally, but perhaps most important, we will continue NASA's internal organizational evolution to ensure that the United States remains a "leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere," as decreed in the National Aeronautics and Space Act of 1958, the legislation that created NASA.

It is our Nation's privilege and obligation to lead the world to places beyond our own and to help shape the destiny of our world for centuries to come. The NASA family, supported by our partners and stakeholders, will lead this visionary program of exploration and discovery on behalf of the American people.

RELIABILITY AND COMPLETENESS OF PERFORMANCE AND FINANCIAL DATA AND FFMIA CERTIFICATION

In submitting this report of our achievements and challenges in FY 2005, NASA accepts the responsibility of reporting performance and financial data accurately and reliably with the same vigor as we conduct our scientific research. For FY 2005, I can provide reasonable assurance that the performance data in this report is complete and reliable. Performance data limitations are documented explicitly.

In accordance with the Federal Financial Management Improvement Act (FFMIA), NASA's Integrated Financial Management System Core Financial Module (IFMSCFM) produces financial and budget reports. However, because of unresolved data conversion issues, the system is unable to provide reliable and timely information for managing current operations and safeguarding assets. Although the IFMSCFM is transactional-based, it does not record all transactions properly at the account detail level required in the U.S. Standard General Ledger. Therefore, NASA's IFMSCFM does not comply fully with the requirements of the FFMIA, and the independent auditors were unable to render an opinion on our FY 2005 fi nancial statements. Instead, they issued a disclaimer of opinion. Therefore, I cannot provide reasonable assurance that the financial data in this report is complete and reliable. We will continue to focus on bringing the system into compliance.

It is my pleasure and privilege to submit NASA's FY 2005 Performance and Accountability Report.

Michael D. Griffin
NASA Administrator

Administrator's Statement of Assurance

NASA submits a qualified Statement of Assurance for Fiscal Year (FY) 2005 because we are reporting four material weaknesses. In response to recommendations of the NASA Operations Management Council, I have agreed to the external reporting of material weaknesses in Space Shuttle Return to Flight, Asset Management, Financial Management System, and Financial Management Data Integrity.

In FY 2005, the Space Shuttle completed STS-114, the first of a planned two-flight program to test and validate the improvements made to the Space Shuttle during Return to Flight. The second test flight, STS-121, was delayed due to the safety implications of unexpected external tank foam-loss events observed during STS-114's ascent. The causes of these events are being resolved and, after reviewing the Space Shuttle flight schedule, STS-121 is targeted for launch in FY 2006. This material weakness will be targeted for closure in FY 2006 pending the completion of planned test and validation activity associated with STS-121.

For FY 2005, I am also reporting three material weaknesses assigned primarily for correction to the NASA Chief Financial Officer (CFO): (1) Asset Management; (2) Financial Management System; and (3) Financial Management Data Integrity. The CFO will develop corrective action plans with Offices of the Integrated Enterprise Management Program, Infrastructure and Administration, the Chief Information Officer, and Procurement.

NASA's summary of its four material weaknesses included in the FY 2005 Performance and Accountability Report is discussed below.

Michael D. Griffin
Administrator

Space Shuttle Return to Flight

NASA's Return to Flight process has been guided by the 15 Return to Flight recommendations of the *Columbia* Accident Investigation Board and the Space Shuttle program's internally generated "raise the bar" actions. NASA's implementation of the Board's Return to Flight recommendations has been independently assessed by the Return to Flight Task Group. NASA's overall Return to Flight progress has been documented in the periodically updated *Implementation Plan for Space Shuttle Return to Flight and Beyond.*

On August 17, 2005, the Return to Flight Task Group released its Final Report. In it, the Task Group unanimously closed out all but three of the Board's Return to Flight recommendations. The Task Group could not reach consensus on whether NASA's actions fully met the intent of three of the Board's most challenging recommendations: External Tank Thermal Protection System Modifications (3.2-1), Orbiter Hardening and Impact Tolerance (3.3-2) and Thermal Protection System On-Orbit Inspection and Repair (6.4-1). The Task Group noted NASA had made substantial progress relative to these recommendations, and emphasized that, "The inability to fully comply with all of the [Board's] recommendations does not imply that the Space Shuttle is unsafe." The first two Return to Flight missions, STS-114 and STS-121, will provide the data and flight experience needed to address the remaining open issues in these recommendations. This work will be documented in future updates to the *Implementation Plan.*

NASA made the decision to proceed with the launch of STS-114 on July 26, 2005, based on the Return to Flight Task Group's assessment, the totality of improvements made to the Space Shuttle system during Return to Flight, and the vetting of all these improvements through a rigorous and multilayered engineering review process.

Postflight analysis of STS-114 indicated that, except for one event, the thermal protection system on the external tank performed within expected parameters. Most of the small foam shedding events that were observed with the newly upgraded imagery and sensor capabilities posed little or no threat to the orbiter. The one event of concern was the loss of an approximately one pound piece of foam from the area of the external tank's liquid hydrogen protuberance air load (PAL) ramp. NASA commissioned two teams (one led by the Space Shuttle propulsion manager, the other an independent "Tiger Team" reporting directly to the Associate Administrator for Space Operations) to analyze these foam-loss events and recommend any forward work that would have to be done prior to the launch of the next mission, STS-121.

As of September 2005, NASA is reviewing flight opportunities for future missions, given the effects of Hurricane Katrina (which caused extensive damage to the area around the External Tank manufacturing facility near New Orleans) on ongoing foam-loss troubleshooting and normal processing activities. NASA is targeting the May 2006 launch window as the next opportunity to launch STS-121.

Asset Management

The material weakness that was identified as Contractor-Held Property in last year's Performance and Accountability Report has been renamed and redefined to more accurately describe the scope and complexity of the management challenges associated with accurately reporting the value and maintaining inventory of NASA's property. Asset Management, the new name of the control deficiency, includes two components:

(1) Contractor-Held Property and (2) NASA-Held Property. At the November 2005 Operations Management Council meeting, NASA Senior Officials acknowledged that challenges in Asset Management were multifaceted, cross-functional issues, and the Council tasked the Chief Financial Officer, the Assistant Administrator for Procurement, and the Assistant Administrator for Infrastructure and Administration to jointly develop a plan that will improve management controls over property, plant, equipment, and materials.

Financial Management System

The Integrated Enterprise Management Program's (IEMP) Core Financial System has also been identified as a material weakness due to ongoing challenges related to system configuration and financial reporting issues. In FY 2003, financial data from 10 disparate legacy financial systems that were supported by over 120 subsidiary systems, along with over a decade of historical data, was migrated to a single, integrated Core Financial System. A number of system processing and configuration management issues continue to be identified as NASA works toward stabilization of the system. The Offices of the Chief Financial Officer, the Chief Information Officer, and the Program Executive Officer for the IEMP will jointly craft a plan for correcting this deficiency.

Financial Management Data Integrity

NASA is committed to making improvements in financial management that will yield accurate and timely financial information. To achieve that goal, NASA's Financial Management, Procurement, Infrastructure and Administration, and IEMP communities must partner in developing and implementing process changes that will help ensure accurate information is accumulated and reported in the Core Financial System for all accounts, including Environmental Liabilities and reconciliation of the Agency's Fund Balances with Treasury. The Chief Financial Officer will partner with the Offices of Infrastructure and Administration, Procurement, and the IEMP to develop a sound data integrity plan.

Vision, Mission, Values, and Organization

NASA is the Nation's leading government research and development organization in the fields of aeronautics and space. Together with the Agency's international partners, as well as partners in other federal agencies, the private sector, and academia, NASA uses its unique skills and capabilities to continue the American tradition of exploration and pioneering and to redefine what is possible for the benefit of all humankind.

NASA'S VISION

On January 14, 2004, President George W. Bush announced *A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration*, a new directive for the Nation's space exploration program. The fundamental goal of this directive is ". . . to advance U.S. scientific, security, and economic interests through a robust space exploration program." In issuing it, the President committed the Nation to a journey of exploring the solar system and beyond: returning to the Moon in the next decade, then venturing further into the solar system, ultimately sending humans to Mars and beyond. He challenged NASA to establish new and innovative programs to enhance understanding of the planets, to ask new questions, and to answer questions that are as old as humankind.

NASA enthusiastically embraced the President's directive as the Agency's Vision and published it as *The Vision for Space Exploration* in February 2004. That document embodies the strategy NASA will follow to extend a human presence throughout the solar system.

NASA'S MISSION

Congress enacted 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 humankind. Nearly 50 years later, NASA continues to pursue this mission and responsibly direct, as mandated by Congress, the Nation's civil aeronautics and space activities.

In FY 2005, NASA proudly continued the traditions begun in 1958: utilizing the Agency's unique competencies in scientific and engineering systems to carry out and achieve this mission.

NASA'S VALUES

NASA is privileged to take on missions of extraordinary risk, complexity, and national priority. NASA employees recognize their responsibilities and are accountable for the important work entrusted to them. The Agency's four shared core values express the ethics that guide NASA's behavior. They are the underpinnings of NASA's spirit and resolve.

- **Safety:** NASA's constant attention to safety is the cornerstone upon which the Agency builds mission success. NASA employees are 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.
- **Teamwork:** NASA's most powerful tool for achieving mission success is a multi-disciplinary team of competent people. The Agency builds and values high-performing teams that are committed to continuous learning, trust, and openness to innovation and new ideas.
- **Integrity:** NASA is committed to an environment of trust, built upon honesty, ethical behavior, respect, and candor. Building trust through ethical conduct as individuals and as an organization is a necessary component of mission success.

- **Mission Success:** NASA's purpose is to conduct successful space missions on behalf of the Nation. NASA undertakes these missions to explore, discover, and learn. And, every NASA employee believes that mission success is the natural consequence of an uncompromising commitment to technical excellence, safety, teamwork, and integrity.

NASA'S STRATEGIC MANAGEMENT AND GOVERNANCE PRINCIPLES

In August 2005, NASA published its Strategic Management and Governance Handbook. This new document describes the process and principles of strategic management for NASA. It provides an overview of core strategic management requirements that explain how NASA is managed and what internal and external requirements drive these management strategies.

The guiding principles of NASA's Strategic Management approach are the following:

- Lean Governance;
- Responsibility and Decision-Making;
- Sensible Competition;
- Balance of Power;
- Checks and Balances;
- Integrated Financial Management;
- Strategic Management of Capital Assets; and
- Strategic Management of Human Capital.

These Strategic Management Principles support an organization that is focused on a challenging Vision, driven by an inspiring Mission, and committed to a set of values that define NASA's spirit.

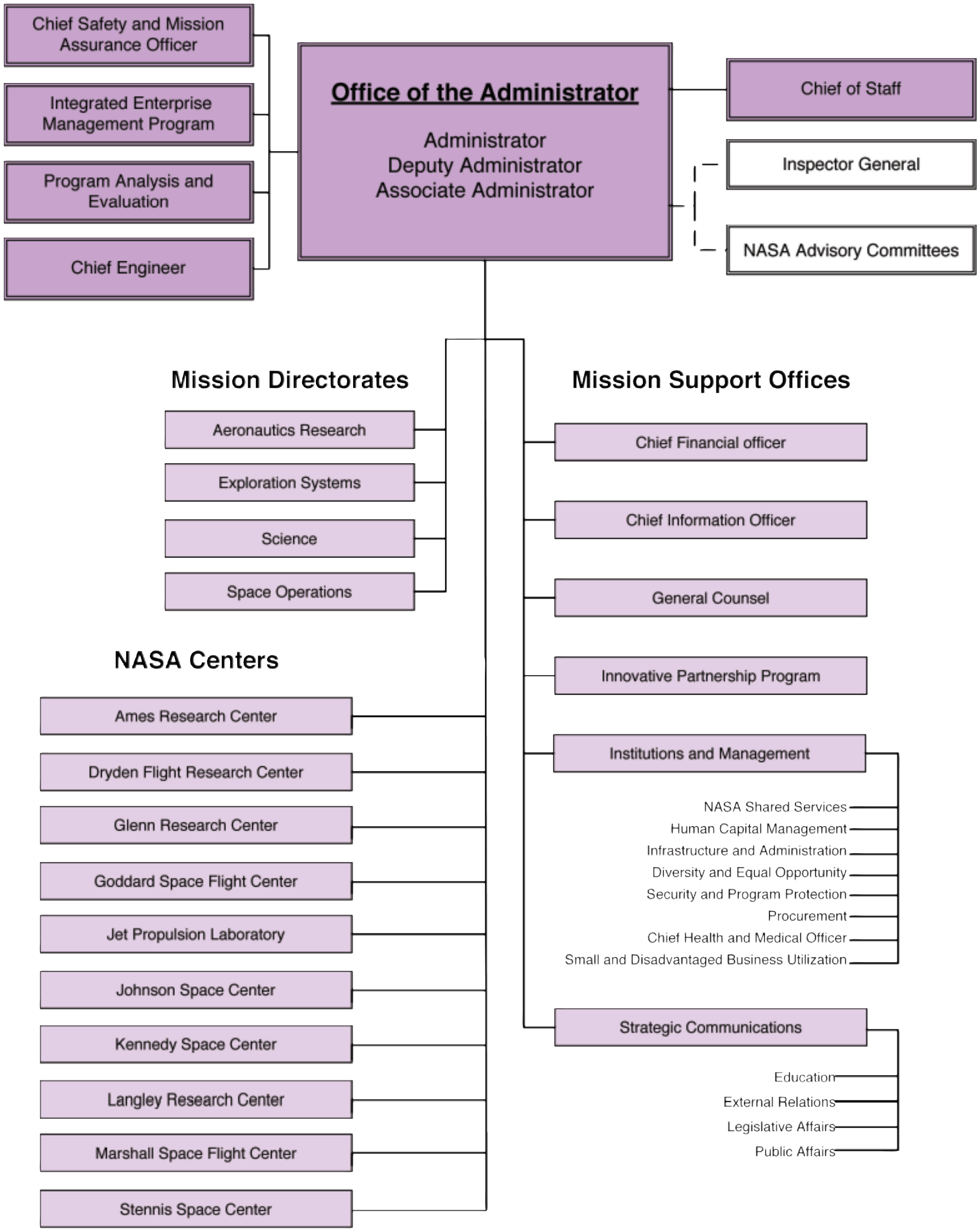
NASA'S ORGANIZATIONAL EVOLUTION

NASA's organization is comprised of NASA Headquarters in Washington, D.C., nine Centers located around the country, and the Jet Propulsion Laboratory, a Federally Funded Research and Development Center operated under a contract with the California Institute of Technology. In addition, NASA has a wide variety of partnership agreements with academia, the private sector, state and local governments, other federal agencies, and a number of international organizations to create an extended NASA family of civil servants, allied partners, and stakeholders. Together, this skilled, diverse group of scientists, engineers, managers, and support personnel share the Vision, Mission, and Values that are NASA.

NASA's organization promotes synergy across the Agency and supports the long-term Vision for Space Exploration. NASA is organized into four Mission Directorates:

- The **Aeronautics Research Mission Directorate** supports research and development in aeronautical technologies for safe, reliable, and efficient aviation systems;
- The **Science Mission Directorate** carries out the scientific exploration of the solar system and beyond, to chart the best route of discovery, and to reap the benefits of Earth and space exploration for society;
- The **Exploration Systems Mission Directorate** develops capabilities and supporting research and technology that enable sustained, affordable, human and robotic exploration, including the biological and physical research necessary to ensure the health and safety of crews during long-duration space flight; and
- The **Space Operations Mission Directorate** directs space flight operations, space launches, and space communications, as well as manages the operation of integrated systems in low Earth orbit and beyond.

The Mission Support Offices and Headquarters Functional Staff Offices, as well as a number of active councils and advisory bodies, also are important members of the Agency's senior leadership team.

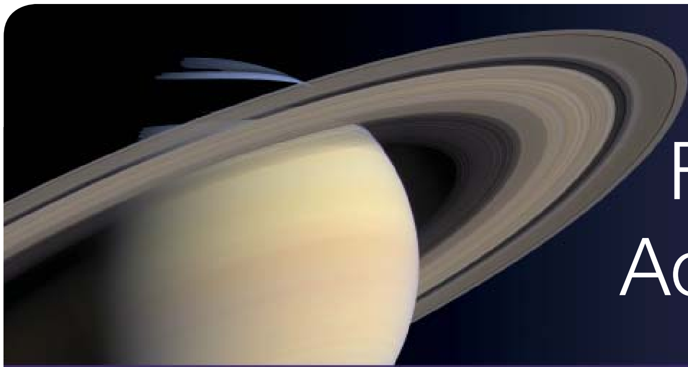


IN PURSUIT OF ONE NASA

The opportunities and challenges associated with achieving the Vision for Space Exploration are exciting. Success will require that all parts of the Agency act as One NASA team to make decisions for the common good, collaborate across traditional boundaries, and leverage the Agency's many unique capabilities in support of a single focus: exploration.

To achieve the goal of One NASA, the Agency is using common business and management tools to improve the effectiveness of cross-Agency operations. NASA has implemented standard practices in human capital management that support and encourage increased teamwork and Agency-wide perspectives. The Agency is improving communication and information sharing so everyone in NASA can contribute more effectively. Finally, NASA has initiated new activities, like NASA's Shared Services Center, a concept that will consolidate like Center services to reduce costs, leverage efficiencies, and share lessons learned across the Agency.

Efforts toward becoming One NASA continue as NASA focuses on identifying and removing impediments to mission success and encouraging increased collaboration across Center boundaries. Cross-Agency teams are targeting improvements in funds transfer between Centers by creating a set of collaborative tools to facilitate working across geographic boundaries. Also, NASA developed, implemented, and published a set of common Agency-wide guidelines on "sensible competition."



FY 2005 Performance Achievement Highlights

The Performance Achievement Highlights discussed in Part 1 of this report reflect NASA's FY 2005 accomplishments in pursuing the Agency's 18 long-term Objectives.

The FY 2005 Performance Achievement Highlights are organized into three focus areas—Life on Earth, Working in Space, and Exploring the Universe—that showcase many of NASA's most significant program areas and spotlight some of the tangible benefits that NASA provides to the Nation. Following the FY 2005 Performance Achievement Highlights is a table of performance ratings that reflects NASA's progress toward achieving the Agency's multi-year Outcomes and a discussion of NASA's performance system.

RETURNING TO FLIGHT

NASA's biggest achievement in FY 2005 was returning the Space Shuttle safely to flight. The Shuttle *Discovery* return to flight mission (STS-114) lifted off the launch pad at the Kennedy Space Flight Center on the morning of July 26, 2005, after being grounded for more than two years following the *Columbia* accident in 2003. During those two years, hard-working teams scrutinized every aspect of Shuttle design and operations and developed ways to improve the Shuttle's safety. Fourteen days after lift off, as *Discovery* landed at Edwards Air Force Base in California, NASA declared the mission a success, although it was far from perfect.

NASA's return to flight efforts did not conclude with *Discovery*'s landing on August 9. The next test flight to the International Space Station, mission STS-121, is scheduled for May 2006, and work continues to resolve remaining anomalies. "We are giving ourselves what we hope is plenty of time to evaluate where we are," said Administrator Mike Griffin in mid-August. "We don't see the tasks remaining before us being as difficult as the path behind us."

Top far left: In May, NASA rolled the Shuttle from the launch pad back to the Vehicle Assembly Building at Kennedy to take care of liquid hydrogen cut-off sensors that malfunctioned during a tanking test (left). *Discovery* was given a new external tank and a new heater to minimize potential ice and frost buildup on the main engines' feedline bellows. (Photo: NASA)

Bottom far left: STS-114 was the most watched launch in history—but not necessarily by human eyes. More than 100 cameras watched *Discovery* from every angle. A high-resolution camera saw a 24- to 33-inch-long piece of insulation foam come off the external tank during the launch. Engineers, damage screeners, image analysts, and thermal protection system experts scrutinized pictures of the Shuttle's nose cap and wing leading edges for subtle signs of damage. Though the screeners flagged about 130 small scuffs, spots, and skid marks, none of them turned out to be cracks in the reinforced carbon–carbon panels. (Photo: NASA)

Left: Once on orbit, the International Space Station crew gave the Shuttle a thorough going-over as Commander Eileen Collins guided it through the first-ever back flip. Again, attention to detail paid off when the Station crew spotted gap filler jutting out between the heat shield tiles. Shuttle crewmember Steve Robinson rode the Station's robotic arm to reach *Discovery*'s underside, where he easily pulled out two gap fillers and completed the first-ever on-orbit Shuttle repair. With all potential problems fixed, the Shuttle crew continued their other mission tasks and safely returned home. (Photo: NASA)

Return to Flight Milestones

August 2003 The Columbia Accident Investigation Board (CAIB) released its recommendations to improve Shuttle safety.

September 2003 NASA released the first draft of its *Implementation Plan for Space Shuttle Return to Flight and Beyond*, outlining steps the Agency would take to prepare the Shuttle for flight.

March 2004 Engineers conducted non-destructive evaluations of the reinforced carbon–carbon panels on *Discovery*'s wing leading edges in response to CAIB's finding that debris from the external tanks had damaged some of *Columbia*'s panels during launch.

November 2004 Engineers assembled the solid rocket boosters in the Vehicle Assembly Building at NASA's Kennedy Space Flight Center, Florida.

December 2004 NASA engineers installed three main engines on *Discovery* (the STS-114 vehicle), the last major components added before crews rolled the Shuttle from the Orbiter Processing Facility to the Vehicle Assembly Building for final stacking.

January 2005 The redesigned, 15-story-tall external tank was delivered by barge to Kennedy.

Engineers installed the Shuttle's new orbital boom sensor system. Attached to the manipulator arm, the system can image the entire length of the Shuttle while in space, fulfilling a CAIB recommendation.

February 2005 Crews attached new carrier panels, which fit between the reinforced carbon–carbon panels and the orbiter, to further protect wing leading edges.

March 2005 Crews mated *Discovery* to the external tank and solid rocket boosters and placed it on the mobile platform.

April 2005 After *Discovery* arrived at the launch pad, it underwent a tanking test where the external tank was filled to launch levels with propellants. Two of four hydrogen sensors inside the tank that control the main engine shutdown sequence when the Shuttle reaches space did not operate correctly. After a thorough review of the sensor system, NASA returned *Discovery* to the Vehicle Assembly Building, where the Shuttle received a new external tank.

June 2005 NASA constructed two new radar antenna dishes on North Merritt Island, Florida. This was the last addition to the improved tracking system recommended by CAIB. NASA also returned *Discovery* to the launch pad.

July 2005 NASA scrubbed the first July launch attempt after a fuel sensor inside the external tank failed a routine pre-launch check. After extensive testing, the sensor performed correctly and officials approved a late-July launch.

Return to Flight, July 26th, 2005

STS-114 launched at 10:39 am EDT. The mission included Commander Eileen Collins, Jim Kelly, Charlie Camarda, Wendy Lawrence, Steve Robinson, Andy Thomas, and Soichi Noguchi of Japan, along with new equipment and supplies for the International Space Station.

New high-resolution cameras on the launch tower spotted a piece of foam coming off *Discovery*'s external tank during launch. Collins took *Discovery* through a first-ever back flip while it orbited 600 feet outside the Station, a maneuver added to Shuttle procedures so that Station crew could search the Shuttle's exterior for possible damage caused during launch. The Station crew spotted loose gap-filler sticking out between heat-shielding tiles on *Discovery*'s belly.

During three separate spacewalks, Robinson and Noguchi tested new repair techniques for the outer skin of the Shuttle's heat shield, installed equipment outside the Station, and repaired one of the Station's control moment gyroscopes. They also replaced another failed gyro, returning all four gyros to service. Robinson successfully removed the loose gap-filler spotted during *Discovery*'s back flip, marking the first time an astronaut worked on the underside of the Shuttle in space.

Discovery successfully landed at Edwards Air Force Base, California, on the morning of August 9th. NASA officials chose this alternate landing site due to weather conditions at Kennedy. A few days later, *Discovery* returned to Kennedy on the back of a special 747 carrier jet.

Above: President George Bush greets the STS-114 and Expedition 11 Station crews during a videoconference on August 8, 2005. (Photo: White House/P. Morse)
Far Left: The sun sets behind the tail of the Shuttle Carrier Aircraft and Discovery as they enter the mate/demate device at Kennedy Space Center. The aircraft had delivered the Shuttle from Edwards Air Force Base, California, where it had landed on August 9, 2005. (Photo: NASA)
Left: As Discovery approaches launch pad 39B on June 15, 2005, the canister that delivered the STS-114 payloads to the pad departs. (Photo: NASA)

Life on Earth

When most people think of NASA, they picture astronauts, rovers on Mars, and the deepest reaches of the universe. As the Nation's civil space organization, NASA focuses many of its capabilities on exploring Earth's cosmic neighborhood. But this is only one way that NASA uses its capabilities for the benefit of the Nation.

NASA provides the "eyes in the sky" to observe natural and human-induced Earth phenomena that affect everyone's lives, including weather, air quality, earthquakes, ocean health, and land use. NASA's fleet of Earth-orbiting satellites and research aircraft produce the data and tools necessary to explore Earth system interactions to understand and predict the courses and consequences of change.

While some satellites focus on Earth, others turn their eyes toward the Sun. This magnetically variable star plays a central role in maintaining life on Earth. However, the space weather it creates can wreak havoc on technology on the ground and in the air. NASA studies the Earth–Sun system to help scientists better understand and predict the effects space weather has on Earth and the solar system.

NASA also is a global leader in developing aeronautics technologies. With its partners from other government agencies, industry, and academia, NASA is committed to developing tools and technologies that can help improve operations of the air transportation system, the design and manufacture of aircraft, levels of safety, and efficiency of the U.S. air transportation system. The benefits for the public are many: air travel with fewer delays; increased safety across the air transportation system; more air travel options, including more options involving small aircraft; less air pollution; quieter skies; and reduced aircraft fuel consumption, helping to conserve a valuable resource and lowering the cost of air travel.

The top photo is a mosaic of images taken of New Orleans by NASA's Terra satellite in April and September 2000. The bottom photo, taken by the same spacecraft, shows New Orleans on September 15, 2005, with flooding caused by Hurricane Katrina. The flooded parts of the city appear dark blue, such as the golf course in the northeast corner, where there is standing water. Areas that have dried out appear light blue gray, such as the city park in the left middle. On the left side of the image, the failed 17th Street canal marks a sharp boundary between flooded city to the east, and dry land to the west. (Photos: NASA)

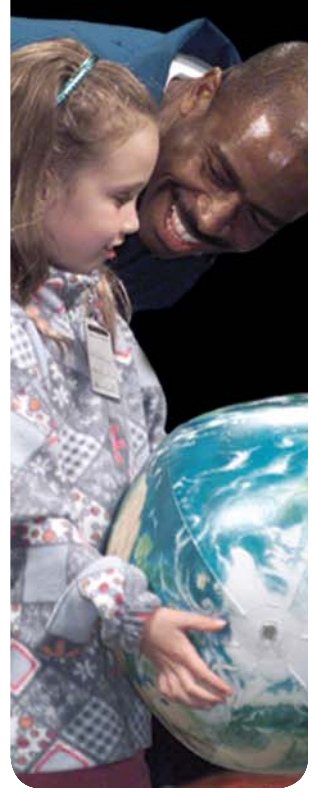
Finally, the Agency strives to share its technologies, skills, and knowledge with the greater community through partnerships, technology transfer programs, public outreach efforts, and education activities. NASA appears in many unexpected places—consumer products, vehicles, weather reports, and the classroom—to make life on Earth better.

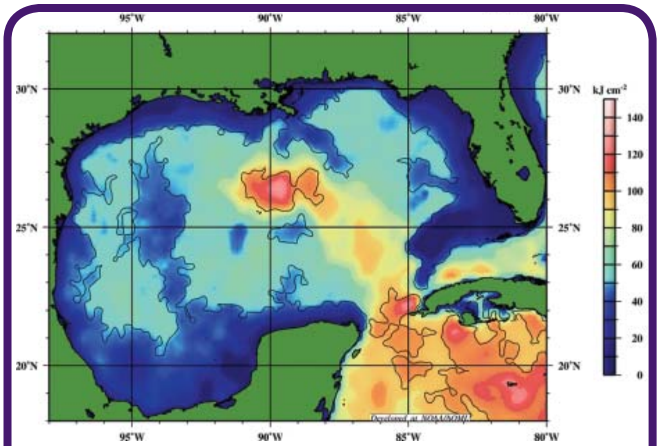
A YEAR OF HURRICANES

NASA lends helping "eyes"

NASA's Earth-observing "eyes in the sky," including Earth-orbiting satellites, aircraft, and the International Space Station, provided detailed images of the flooding and devastation in areas affected by Hurricanes Katrina and Rita. NASA, along with academic institutions and partner agencies, worked to ensure that the Department of Homeland Security and the Federal Emergency Management Agency had the best available information to aid the rescue and recovery effort. The images and associated data helped characterize the extent of the flooding, the damage to homes, businesses, and infrastructure, and the potential hazards caused by the storms and their aftermath.

NASA used its Experimental Advanced Airborne Research Light Detection and Ranging system, carried aboard a Cessna 310 aircraft, to survey the Gulf of Mexico coastline. The system can "see" through vegetation, like trees and shrubs, to view the land underneath. Near the coast, it mapped the beach surface under water. This helped the U.S. Geological Survey, the Federal Emergency Management Agency, and the Army Corps of Engineers determine the state of the shoreline infrastructure, identify hazards, and study environmental loss.





This image shows near-real-time estimates, developed by NOAA using data from several NASA Earth observing satellites, of upper ocean heat content and tropical cyclone heat potential in the Gulf of Mexico on August 28, 2005. Additional research showed that Hurricane Katrina intensified as it passed over the Loop Current, visible in the center of the image. (Image: NOAA/AOML)

Watching from space as storms heat up

Throughout the hurricane season, NASA observed the upper ocean thermal conditions in the Gulf of Mexico. Research shows a link between the intensification of hurricanes in the region and oceanic heat content. In late August 2005, when Katrina passed over the Loop Current and a large warm eddies called the core ocean ring, it evolved quickly from a category 3 to category 5 hurricane in only nine hours. The warm waters of the Loop Current appear to have rapidly fueled the storm while the warm core rings seemed to have sustained the storm's intensity.

NASA and the National Oceanic and Atmospheric Administration (NOAA) are studying this phenomenon to confirm if oceanic heat content plays a major role in hurricane intensity. Researchers use satellite altimetry data, including data from NASA's TOPEX/Poseidon and Jason-1 missions, to calculate in near-real time the tropical cyclone heat potential, a measure of the vertical temperature of the upper ocean. Satellite altimeters also search for warm pockets of water in the ocean that could fuel a passing tropical storm or hurricane. The Loop Current has warmer waters at greater depth than the surrounding ocean, as well as different salinity. These differences create variations in the sea surface height that can be detected from space and incorporated into the study.

Studying the birth of tropical storms and hurricanes

This year NASA conducted the Tropical Cloud Systems and Processes mission, designed to study the factors that influence the genesis and rapid intensification of tropical cyclones. During the Costa Rica-based mission, scientists tracked two major Atlantic Ocean hurricanes at the height of their destructive power, witnessed the entire lifecycle of tropical storms in the Atlantic, and documented a number of unexpected surprises about the short, violent lives of these seagoing tempests.

The mission documented "cyclogenesis," the mysterious formula of rainfall, air and sea temperature, pressure, and other factors required to spawn tropical storm systems. By studying the complex processes that form tropical storms, scientists will gain a better understanding of how hurricanes evolve, intensify, and travel—the key to developing earlier, more accurate warning systems.

Partnering with NOAA and the Costa Rican Centro Nacional de Alta Tecnologia, NASA spent July conducting ground-based and airborne studies of tropical storm systems on Costa Rica's east and west coasts. The team primarily intended to investigate the birthplace of eastern Pacific tropical cyclones, which they did in detail, but an early start to a record-breaking, busy Atlantic hurricane season added numerous other research opportunities to the mission.

The missions used NASA and NOAA aircraft, satellites, balloon-borne weather probes, and remotely operated aircraft to investigate the lifecycle of Hurricane Dennis, from genesis through post-landfall, a disturbed region of the Eastern Pacific that likely gave birth to Tropical Storm Eugene, and the complete lifecycle, from genesis to landfall, of Hurricane Gert. These data sets represent the first time that anyone has sampled the full life cycle of a single tropical cyclone. Scientists will collate and analyze the enormous amount of data for more than a year.

Taking a closer look at hurricanes

While satellites searched for warm water in the Gulf from space, NASA also took a closer look at the environment where the atmosphere meets the sea, the critical zone where the ocean's warm water transfers energy to a growing storm. On September 16, 2005, NASA, NOAA, and Aerosonde North America launched a remote-controlled aircraft into Hurricane Ophelia as it sat off the coast of Georgia and the Carolinas.

The Aerosonde remote-controlled aircraft is released from its transport truck on the runway at NASA's Wallops Flight Facility, Wallops Island, Virginia. It was sent down the coast to fly through Hurricane Ophelia, a low-energy hurricane. (Photo: NASA)

The aircraft, known as an Aerosonde, was equipped with sophisticated instruments that recorded temperature, pressure, humidity, and wind speed in real time and relayed the information back to the researchers. The resulting data provided the first-ever detailed observations of the high-wind area where a hurricane meets the sea surface, an area often too dangerous for piloted aircraft to observe directly. NASA pioneered the use of aerosondes in other tropical convection experiments in 2001 and 2005, but this was the first time the Aerosonde flew into a hurricane.

The December 2004 Indonesian earthquake caused a massive tsunami to wash over 10 countries in South Asia and East Africa. This pair of images from NASA's Terra satellite shows the Aceh province of northern Sumatra, Indonesia, on December 17, 2004, before the earthquake (top), and on December 29 (bottom), three days after. The earthquake also changed Earth's shape slightly. (Photo: NASA)

The Aerosonde, along with piloted aircraft and Earth-observing satellites, are helping scientists and forecasters better predict hurricane intensity and behavior. Enhancing this predictive capability would save the United States billions of dollars, and—more importantly—save lives.

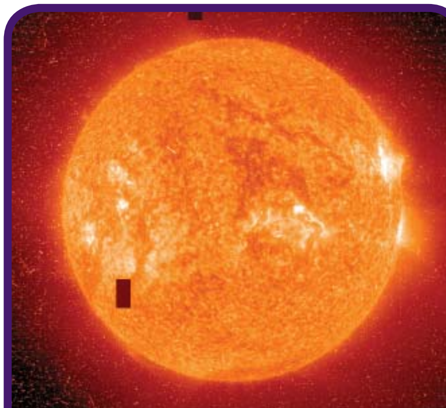
EARTH'S CHANGING SHAPE

This year, NASA scientists learned more about forces that continually change Earth's shape. Single events like the Indonesian earthquake in December 2004, and seasonal climate events like El Niño, can cause measurable changes in the Earth system.

The massive earthquake off the west coast of Indonesia on December 26, 2004, registered a magnitude of nine on the new "moment" scale (a modified Richter scale) that indicates the size of earthquakes. It was the fourth largest earthquake in one hundred years and the largest since the 1964 Prince William Sound, Alaska earthquake. In addition to the massive tsunami that washed over 10 countries in South Asia and East Africa, NASA found that the earthquake caused permanent changes to the Earth's structure.

Using Earth observations from before and after the Indonesian earthquake, NASA scientists calculated that it slightly changed the planet's shape; the Earth's oblateness (flattening on the top and bulging at the equator) decreased by a small amount and the North Pole shifted by about 2.5 centimeters. The earthquake also increased the Earth's rotation and decreased the length of day by 2.68 microseconds. Physically, this is like a spinning skater drawing their arms closer to the body resulting in a faster spin.

Scientists using NASA satellite data found that Earth's shape also appears to be influenced by climate events like the El Niño Southern Oscillation and Pacific Decadal Oscillation that affect the amount of water moving in the oceans, atmosphere, and continents. The study results showed that significant variations in Earth's shape over the past 28 years might be linked to climate events.



SOHO's Extreme-ultraviolet Imaging Telescope captured this image of an intense solar flare on January 20, 2005. The flare—the most intense in 50 years—is visible along the center right edge of the Sun. A flare is caused when magnetic field lines stretch and twist over sunspots on the surface until they build up enough energy to snap open, forming a tongue-like shape. (Photo: ESA/NASA)

SOLAR FLARE SPARKS SPACE WEATHER MYSTERY

Space may look empty, but it is filled with dust, debris, and dynamic forces generated by the Sun, including radiation hazardous to astronauts and satellites. On January 20, 2005, the space around Earth was filled with radiation when a large solar flare blasted out the most intense burst of solar radiation in five decades.

Normally, it takes two or more hours after a flare on the Sun for the blast of solar radiation to reach maximum intensity at Earth. In January, the solar protons released by a massive flare—accelerated to nearly light speed by the explosion—reached Earth and the Moon only minutes later, beginning a days-long "proton storm" that altered existing theories about the origin of proton storms around Earth. "Since about 1990, we've believed that proton storms at Earth are caused by shock waves in the inner solar system as coronal mass ejections plow through interplanetary space," said Robert Lin of the University of California at Berkeley, principal investigator for the

NASA's F/A-18A maneuvers through a test point for the Active Aeroelastic Wing project on December 15, 2004. The stock aircraft was modified with a thinner, more flexible wing skin and structure, new flight control computer software, and a number of sensors that track the wings' flexibility and strain. (Photo: NASA/C. Thomas)

Reuven Ramaty High Energy Solar Spectroscopic Imager (also known as RHESSI). "But the protons from this event may have come from the Sun itself."

No one suffered from the January 20th solar event thanks to the thick atmosphere and magnetic field that protect Earth and its inhabitants from solar radiation. However, high-energy protons ionized the upper atmosphere, disrupting electrical devices and communication signals. Astronauts on the International Space Station were safe, as well, since the Station is heavily shielded and orbits inside Earth's magnetic field. The Moon, however, is totally exposed to solar flares. It has no atmosphere or magnetic field to deflect radiation, so protons rushing at the Moon simply hit the surface. An astronaut caught on the Moon's surface when the storm hit may have gotten sick and exhibited symptoms of radiation sickness: vomiting, fatigue, and low blood counts. Solar radiation storms hitting the Moon also would affect exploration vehicles, like robotic explorers. Therefore, to protect astronauts and space vehicles on the way to the Moon or on the surface, NASA and its partners are developing technologies that can predict solar flares, coronal mass ejections, and geospace storms, part of what is called "space weather." The Transition Region and Coronal Explorer (TRACE), the Advanced Composition Explorer (ACE), the Solar and Heliospheric Observatory (SOHO), Wind, and the RHESSI spacecrafts are the space community's early warning system, spotting solar activity before it reaches Earth and helping scientists to identify the causes of flares and coronal mass ejections. The result is improved forecasting, better solar flare prediction, improved planning and better shielding from bursts that could disrupt radio transmissions, cellular communications, and satellite service.

A NEW TWIST ON AN OLD WING

Warping an aircraft's wing to improve turning ability is a concept as old as powered flight. The Wright brothers used cables attached to the wingtips of their 1903 Flyer to twist the wing and turn the airplane. Now, NASA has put a 21st century twist on wing-warping. NASA and its partners, the U.S. Air Force Research Laboratory and Boeing, are evaluating active control of lighter-weight, more flexible wings for improved maneuverability of high-performance military aircraft through the Active Aeroelastic Wing project.

In March 2005, the project team concluded its second phase of flights in an F/A-18A aircraft. The test evaluated the ability of software installed in the F/A-18A's flight control computer to react accurately to the flexible wings' movements during twisting maneuvers at various speeds and altitudes. The updated flight control software, developed through extensive testing of aeroelastic wings conducted during the project's first flight phase in late 2002 and early 2003, controls the aircraft in accordance with the wings' movements, guiding the aircraft through turns and rolls.

The Active Aeroelastic Wing concept is intended primarily to benefit aircraft that operate at approximately 80 to 120 percent of the speed of sound (about 761 miles per hour), where traditional wing-control surfaces become progressively ineffective. The project team's next task will be spreading the Active Aeroelastic Wing design philosophy to the aeronautics technical community. The team anticipates that the benefits realized through the Active Aeroelastic Wing project will include faster, more capable military aircraft with potentially reduced radar signatures, lighter high-altitude, long-endurance uncrewed aircraft, and more fuel-efficient and affordable commercial airliners.

A technician installs a TAMDAR sensor in a Saab 340 commuter airliner at Mesaba Airlines. The Mesaba Airlines fleet will carry the sensors for a year as part of the Great Lakes Fleet Experiment, an operational test of the sensors' ability to provide timely weather forecasts. (Photo: D. Jackson/Mesaba Airlines)

BIG HELP FOR SMALL AIRCRAFT: NASA PROVIDES BETTER WEATHER INFORMATION

Large airliners fly above most weather, but for small, regional aircraft that typically fly below 25,000 feet, weather can be a major problem. With the help of airborne sensors installed on a fleet of commuter airlines, NASA is providing small aircraft pilots with better weather information.

A NASA-led team designed, built, and equipped dozens of Mesaba Airlines aircraft with the Tropospheric Airborne Meteorological Data Report (TAMDAR) instrument that allows aircraft flying below 25,000 feet to detect and report atmospheric conditions. Satellites then send the aircraft's observations to a ground data center that processes and distributes up-to-date weather information to forecasters, pilots, and other aviation personnel.

The compact TAMDAR sensor weighs only 1.5 pounds. It measures humidity, winds, pressure, temperature, icing conditions, and turbulence with the help of location, time, and altitude data provided by a built-in Global Positioning System. The team chose Minneapolis-based Mesaba Airlines to test the sensor because it is a regional airline with a large prop-jet fleet that flies in an area with challenging weather conditions.

The team began an extensive test of the system, called the Great Lakes Fleet Experiment, in January 2005. It will run through January 2006. During this time, the team will make the TAMDAR data available to the public, and users will complete surveys to gather feedback as a way to validate the system and improve service.

In addition to helping small aircraft pilots, the TAMDAR data will improve weather forecasts and weather forecasting models by increasing the number of observations in the lower atmosphere. Currently, there are only 90 weather balloon sites nationwide that are used to collect temperature, wind, and moisture data from twice-daily atmospheric soundings. The Great Lakes Fleet Experiment will add 1,300 more atmospheric soundings per day, increasing forecast accuracy.

NASA HELPS PREVENT AIR TRAFFIC BOTTLENECKS

Air traffic bottlenecks paralyze busy sections of the U.S. airspace, costing airports money and travelers precious time, and making the skies around major airports increasingly dangerous. But thanks to the Multi-center Traffic Management Advisor, a joint project of NASA, MITRE Corporation, and the Federal Aviation Administration (FAA), this scenario may become a problem of the past.

At the heart of the Multi-center Traffic Management Advisor is a powerful "trajectory synthesis" engine that converts radar data, flight plans, and weather information into highly accurate forecasts of air traffic congestion. The Multi-center Traffic Management Advisor uses these forecasts, along with input from air traffic personnel, to generate a specific advisory—usually a small take-off delay—for each aircraft predicted to meet congestion at its next destination. The result, is fewer airborne traffic jams at busy airports.

Traffic management advisors sit at consoles at Denver's Terminal Radar Approach Control. Denver and several other center's currently use an older version of the Multi-center Traffic Management Advisor to schedule arrivals and assign runways. (Photo: NASA)

In November 2004, NASA, MITRE, and FAA successfully tested the Multi-center Traffic Management Advisor's management of arrivals to Philadelphia International Airport. The test brought the air traffic control tool closer to full operation. NASA and its partners also conducted other tests at the Air Route Traffic Control Centers in New York, Washington, DC, Boston, and Cleveland, which validated the NASA-developed "distributed scheduling architecture," a key to future advancements in air traffic management.

An earlier version of the system called Traffic Management Advisor develops arrival-scheduling plans for individual airports. It is used to schedule arriving traffic at Dallas–Ft. Worth, Minneapolis, Los Angeles, Denver, Houston, Miami, and Atlanta. The Traffic Management Advisor has reduced passenger delays, maximized airport capacity, and reduced airborne holding. In fact, the FAA estimates that it has saved airspace users more than $180 million and reduced delays by more than 72,000 hours from its implementation in 2002 through January 2005.

Humans have been venturing into space for more than 40 years. Despite these decades of experience, human space flight remains an enormous challenge. A great deal of effort, research, and technology development goes into every mission, and every mission yields accomplishments and lessons learned. Still, NASA continues to look toward the stars and to push the limits of human capabilities and exploration.

As NASA pursues the Vision for Space Exploration, the Agency is focusing on maintaining its current resources, like the Space Shuttle and the International Space Station, for critical space research while developing next-generation space systems and technologies that will help astronauts journey beyond Earth. The human space exploration program of tomorrow will be built on the lessons and technologies of the past 40 years and today.

KEEPING AN EYE ON THE SHUTTLE

When *Discovery* (STS-114) launched on July 26, 2005, it was followed by two NASA WB-57 chase jets tasked with keeping an eye on the Shuttle as it returned to flight. The jets were used originally for high-altitude global climate change studies, but NASA equipped each with an innovative on-board video and recording system called the WB-57 Ascent Video Experiment, or WAVE, to capture visible-light and infrared imagery of the Shuttle on its journey to orbit and to record details of the Shuttle's behavior as it climbed through the atmosphere. The jets kept pace with *Discovery*, maintaining a safe distance of 15 miles, for just over six minutes, and recorded the details of its ascent until the Shuttle flew out of range and the solid rocket boosters dropped away.

After the launch, one jet returned to its home base at Elington Field in Houston, Texas, and the other went to Costa Rica. The plan was that the pilots would follow the Shuttle when it made its reentry and collect reentry information, helping engineers establish a benchmark for a normal reentry that could be used for future missions. Unfortunately, because the landing was moved from NASA's Kennedy Space Center, Florida, to Edwards Air Force Base, California, both jets missed the reentry opportunity.

The goal of the WAVE project is to assure that each launch and landing goes as planned. After determining that a piece of insulating foam from the external tank damaged Shuttle *Columbia*'s wing just after takeoff, the Columbia Accident Investigation Board recommended that NASA improve how it images each launch. In response, NASA installed new cameras around the launch tower, added radar tracking for the Shuttle, and developed a concept for chase planes that led to the WAVE project.

"This was the very definition of a team effort," said NASA engineer John West of the Space Optics and Manufacturing Center. "In June 2004, we were looking at nothing more than a concept on a drawing board. In nine months, we built two complete imaging systems." NASA teamed with industry to build the high-definition imaging system, its precision-controlling software, and housing. The team's hard work resulted in an imaging system that provides NASA with a new way to assess Shuttle performance and the public with a new way to ride along as the Shuttle reaches for the sky and beyond.

The WAVE project swiveling video recording system sits on the front of NASA's two WB-57 jets like a bulbous nose. The primary optic lens, a 4,150-millimeter reflector telescope, is visible on the right of the spherical turret. NASA partnered with Southern Research Institute, who design gimbal systems for the U.S. Army, to design a large, rotating gimbal to house the cameras that was stable and would remain focused on the speeding Shuttle. (Photo: NASA)

BEYOND SHUTTLE: NASA'S 21ST-CENTURY SPACECRAFT

The Vision for Space Exploration will take space exploration beyond low Earth orbit and extend a human presence across the solar system in safe, affordable, and sustainable increments. During the second half of FY 2005, NASA conducted the Exploration Systems Architecture Study to determine what technologies, knowledge, and infrastructures the Agency will need to return to the Moon and continue on to Mars and beyond. And in September 2005, NASA unveiled its plan for the next-generation human space exploration spacecraft for use after the Shuttle is retired.

NASA's new exploration vehicle, shown in this artist's concept orbiting the Moon, will have solar panels to provide power. The capsule and the lunar lander will use liquid methane in their engines. NASA chose liquid methane as a fuel in anticipation of future Mars missions, where astronauts can convert Martian atmospheric resources into methane fuel. (Image: NASA/John Frassanito and Associates)

The new spacecraft is the centerpiece of NASA's 21st-century exploration system. It will carry four astronauts to and from the Moon, support up to six crewmembers on future Mars missions, and deliver crew and supplies to the International Space Station. The spacecraft will be shaped like an Apollo capsule, but will be three times larger and reusable up to 10 times.

The crew vehicle will launch on a rocket comprised of a single Shuttle solid rocket booster, with a second stage powered by a Shuttle main engine. A second, heavy-lift system will use a pair of longer solid rocket boosters and five Shuttle main engines to put up to 125 metric tons in orbit—about one and half times the lift capability of the Shuttle. This versatile system will be used to carry cargo and to put the components needed to go to the Moon and Mars into orbit. It can be modified to carry crew, as well.

NASA's new launch systems will be safer than the Shuttle thanks to an escape rocket on top of the capsule that can quickly carry the crew away if launch problems develop. And since the vehicle will sit on top of the rocket in both configurations, there is minimal chance of the vehicle being damaged by debris during launch.

While NASA and its partners build the new launch systems and vehicle, robotic missions will lay the groundwork for lunar and Mars exploration. These missions will include rovers and orbital spacecraft searching for potential landing sites and resources, such as oxygen, hydrogen, and metals.

The next planned human lunar mission, a seven-day flight, is planned for 2018. Additional short missions will give crews the opportunity to conduct research and slowly establish a lunar outpost to enable longer stays. The lunar outpost, just three days away from Earth, will enable NASA explorers to practice "living off the land" before embarking on longer treks to Mars and beyond.

NASA'S X-43A SCRAMJET SPEEDS INTO THE RECORD BOOKS

NASA's B-52B mothership carries the X-43A, attached to the nose of a Pegasus rocket booster, under its wing on November 16, 2004. The body of the small, slim X-43A (inset artist's concept) forms critical elements of the vehicle's design. The forebody acts as part of the intake for airflow and the aft section serves as the nozzle. (Photo: C. Thomas/NASA; drawing S. Lighthill)

Like a meteorite blazing over the Pacific Ocean near sunny southern California, NASA's X-43A experimental supersonic combustion ramjet, or scramjet, flew at nearly 10 times the speed of sound on November 16, 2004. The X-43A's Mach 9.6 flight—nearly 7,000 mph—broke the world's speed record for an air-breathing jet-engine flight set by the same scramjet earlier in the year when it flew at Mach 6.8. Before this, the world's fastest air-breathing aircraft, the SR-71, only achieved slightly over Mach 3.

At 40,000 feet, a modified Pegasus rocket booster left NASA's B-52B aircraft and carried the unpiloted X-43A up to 110,000 feet. At this point, the X-43A blasted off and accelerated on scramjet power for a 10-second flight at nearly Mach 10.

In the past, only rocket-powered vehicles could reach hypersonic speeds (speeds exceeding Mach 5), but those vehicles needed to carry large amounts of fuel and an oxydizer (to feed the fuel with the oxygen it needs to burn), making them large, heavy, and impractical. The X-43A, however, has an air-breathing engine that scoops oxygen molecules out of the thin upper atmosphere as air passes through it and uses these molecules to keep the fuel burning. Once accelerated to Mach 4 by a conventional jet engine or booster rocket, the X-43A scramjet can fly at hypersonic speeds without carrying heavy oxygen tanks.

Scramjets have the capability of being throttled back and flown more like airplanes, unlike rockets that usually produce full thrust all the time. The scramjet has the added benefit of being reusable like a conventional jet engine. The X-43A's record-breaking flight is a key milestone in NASA's effort to transform experimental scramjet technology into a reliable and affordable way to send large, critical payloads into space, while simultaneously developing hypersonic airplanes to transport people quickly and safely around the world.

TURNING ROBOTS AND COMPUTERS INTO INDISPENSABLE HELPERS

Kim Farrell, Clarissa project manager, tests the safety of drinking water using the voice-activated system in a Station simulation at NASA's Ames Research Center. (Photo: NASA)

The Vision for Space Exploration goal of sending humans to the Moon, Mars, and beyond is based on a partnership between humans and highly capable robotic assistants that can work side-by-side with astronauts or autonomously explore places where humans cannot.

Meet Clarissa

Astronauts undergo extensive training for the technical tasks they must perform on the International Space Station, but they still rely frequently on lengthy procedures manuals as they work. However, when an astronaut's hands are occupied, or the astronaut is in a spacesuit with bulky gloves floating outside the Station, thumbing through a manual is not always practical. In the future, astronauts will rely on Clarissa, a voice-operated, interactive "virtual crew assistant" designed to help ease crewmember workload. The hands-free system, under development at NASA's Ames Research Center, responds to voice commands, and Clarissa can read procedure steps aloud as crewmembers work, keep track of completed steps, and support flexible, voice-activated alarms and timers.

Earlier versions of the system tried to process all spoken words, including conversations between crewmembers, because NASA wanted the system to be ready to assist at any time without requiring artificial activation commands. Therefore, a simple "Star Trek" solution—like having crewmembers address the computer by stating a specific word such as "computer" before posing a question or speaking a command to the system—wasn't a viable solution. Instead, NASA needed to improve the system's ability to discriminate between commands and conversation. With the help of Xerox researcher Jean-Michel Renders, NASA's partner in the project since 2004, Clarissa now analyzes words, sentences, and context with about 95-percent accuracy. In fact, Clarissa currently supports about 75 individual commands that can be accessed using a vocabulary of about 260 words. The team plans to increase the commands and add to the vocabulary in the future.

Clarissa, which is named for its simulated female voice, was installed on the Station in January 2005. It was used for the first time by John Phillips, Expedition 11 Flight Engineer and NASA Science Officer, on June 27. During this test, Phillips completed the interactive Clarissa training procedure, which exercised all of Clarissa's main system functions. The procedure contained 50 steps and took 25 minutes to complete. Afterward, the Clarissa research team pronounced the test a success.

Improvements that make Clarissa a better crew assistant in space are improving the way other computer systems assist people on Earth. For example, Xerox is using the same technology to improve categorization results for printed or digital documents, helping customers manage document content. NASA also is working with scientists at Geneva University to develop the technology for the medical field, helping doctors communicate with patients who do not speak their language.

A team with excellent communication skills

Continuous, fruitful communication between humans and robots was the goal of a spring 2005 field test conducted in Utah's Southeast Desert. During the field test (part of NASA's ongoing Mobile Agents Project), wheeled, prototype "Extravehicular Activity Robotic Assistants" followed geologists around the simulated Mars environment at the Mars Society's Mars Desert Research Station. The project researchers encouraged the robotic assistants to work together to help spacesuited geologists conduct a series of ever-more demanding, human–robot simulated geology missions. The researchers examined how landscape, distance, work

One of the Mobile Agents researchers, dressed in a spacesuit, looks at the computer network relay (center) and a robotic assistant called Boudreaux, which was being teleoperated by a handler. The spacesuits include a communication earpiece and microphone. (Photo: NASA/Mars Society) coordination, and other factors affected operations to determine how they could improve the robots, spacesuits, tools, and work methods. Future long-duration human space exploration will rely on robotic assistants to make science discoveries and construct and maintain human habitats.

The robotic assistants use sensors that are similar to, but often better than, a human's five senses. A Global Positioning System pinpoints each robotic assistant's location, and laser rangefinders help the robots avoid obstacles and plan routes. The robots also have six-axis accelerometers that allow them to judge the slant of the terrain to avoid tumbles. They have manipulator "hand" appendages, pan-tilt cameras, and hitches to pull trailers filled with tools, samples, and equipment, all making them very helpful assistants.

A swarm of robots

In January 2005, NASA engineers watched like anxious parents as their robotic creation, looking like an animated pile of Tinker Toys, scrambled over the rock and snow at McMurdo Station in Antarctica. Their visit to the icy land was to test the tetrahedral walker (TETwalker) in a harsh environment resembling conditions on Mars. The prototype TETwalker consists of electric motors connected to struts, forming a movable pyramid with four sides. The motors lengthen or retract the struts, causing the structure to topple in a desired direction. The motors also pivot to give the robot additional flexibility.

Engineers Ken Lee (right) and Caner Copperrider work on the TETwalker prototype in their laboratory at Goddard Space Flight Center. (Photo: NASA)

The results of the test pointed the team toward modifications that would improve performance. For example, moving the motors to the middle of the struts, instead of at the corners, will simplify the design and increase reliability. But overall, the pyramid shape proved to be strong and stable. If current robotic rovers topple over on a distant planet, they are doomed, because there is no way to send someone to get them back on their wheels. However, the TETwalker moves by toppling over purposely, resulting in a reliable way to get around.

NASA's goal is to create miniaturized robots that can be joined together to form "autonomous nanotechnology swarms" that alter their shape to flow over challenging terrain or to create useful structures, like communications antennae and solar sails. The swarm would be spontaneously adaptable, changing shape to tackle tough terrain and "healing itself" by reshaping around damaged sections like cells replacing damage in the human body. The team also is researching artificial intelligence systems that will allow the robots to move and work together with little input from a human controller—tiny, tumbling TETwalkers working as a unified team.

From Earth to space

NASA and the National Oceanographic and Atmospheric Administration developed an autonomous fleet of aquabots that bring together many of NASA's current robotics capabilities. The aquabots, part of NASA's new platform system called the Ocean–Atmosphere Sensor Integration System (OASIS), are relatively inexpensive, buoy-like boats that can operate autonomously or by controller to gather near-real-time observations of various ocean phenomena. They run on solar power for up to three months and can move continuously through the water at surface speeds up to two knots.

Each aquabot is equipped with NASA's Adaptive Sensor Fleet technology, a control system that allows robotic platforms to respond to science events, such as changes in weather, and to select targets based on data analysis and modeling—all autonomously. The aquabots will be able to track hurricanes, observe ocean conditions, locate oil spills, measure algae blooms, and record other phenomena that are difficult or impossible to measure using Earth observing satellites.

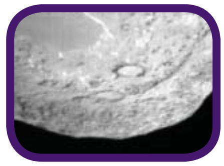
The OASIS aquabots underwent several tests in FY 2005, including the first sea trials during which the research team tested the aquabots' ability to travel independently and to map dye dropped into the ocean. While the OASIS aquabots perform valuable Earth science services, they also will be testing the Adaptive Sensor Fleet technology for use in space exploration.

Looking like a floating doghouse, an OASIS aquabot maneuvers around open water during a test conducted in March 2005. Trailing behind the aquabot (not visible in the picture) was an operator in a chase boat who guided the aquabot with a remote control box. After the test, the team made changes to the propulsion motor/controller, which overheated during the test, to prepare the aquabot for the next phase of testing in the summer. (Photo: NASA)

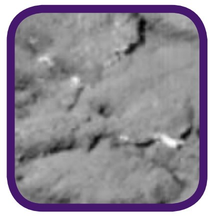
Exploring the Universe

NASA explores the unknown to help humankind answer ancient and fundamental questions: How did we get here? Are we alone? How did the universe begin? How will it end? NASA's partner in this quest is a range of robotic technologies—space telescopes, planetary rovers, and exploration spacecraft—that extend human eyes and hands to places beyond reach.

Within a few years, NASA will have crossed the entire length of Earth's solar system. This fiscal year, the Voyager I spacecraft journeyed into the heliosheath, the point where the Sun's influence diminishes and the solar system ends. The MESSENGER spacecraft passed around Earth to gain a gravity boost in August 2005 on the way to its first flyby of the solar system's Sun-scorched, innermost planet, Mercury, in 2008. NASA also continued to study the solar system's history and to search for water, resources to support future human space exploration, and possible landing sites for future robotic and human missions.



While the heliosheath is the farthest point of NASA's physical presence, NASA and its research partners have looked much farther—to distant galaxies and back in time to the universe's beginning. Using powerful instruments, NASA has seen nebulae giving birth to new stars while watching other stars dying and giving birth to powerful black holes. NASA also has searched for undiscovered planets orbiting distant stars, hoping to find small, terrestrial planets like Earth. Beyond simply spotting distant phenomena, NASA researchers also seek to understand the evolution and composition of the universe: How do its components (from celestial bodies to more elusive dark matter) form? How are space, time, and matter connected? How will the universe evolve in the future?



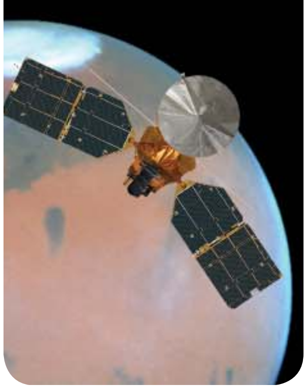
DEEP IMPACT: AN INDEPENDENCE DAY ENCOUNTER CREATES DEEP-SPACE FIREWORKS

On July 4, 2005, NASA scientists created their own fireworks in the sky when part of NASA's Deep Impact spacecraft successfully crashed into a comet. The Deep Impact team members, located more than 83 million miles away at NASA's Jet Propulsion Laboratory, steered the spacecraft, comprised of a subcompact car-sized "flyby" spacecraft and a smaller, washing machine-sized "impactor," toward the comet, Tempel 1, for a first-of-its-kind, planned, high-speed collision with a comet.

After a voyage of 172 days and 268 million miles, Deep Impact's collision with Tempel 1, a nomadic ball of dirty ice and rock orbiting between Mars and Jupiter, was a smashing success. The impact gave scientists a glimpse beneath the comet's surface, where material from the solar system's formation has sat relatively unchanged for billions of years. The 820-pound impactor collided with the comet nucleus at a speed of 23,000 miles per hour, spewing out a spray of vaporized impactor and comet material that glinted in the sunlight like a giant, distant firework—bright enough to be seen by telescopes on Earth.

Deep Impact provided step-by-step images as its probe closed in on Tempel 1 on July 4, 2005, from approximately 5 minutes away (upper left) to several seconds after impact, when sunlight glinting on ejecta created a bright flash visible to the mother spacecraft (above). (Photos: NASA/Caltech/UMD)

The Deep Impact science team theorizes that the impactor vaporized deep below the comet's surface when the two collided, creating a crater and revealing the untouched, primordial material beneath. By observing the impact crater and how it developed, scientists hope to learn the basic structure and density of the comet. The final image from the short-lived impactor was transmitted three seconds before it met its fiery end from a distance of about 18.6 miles from



the comet's surface, allowing scientists to resolve features on the comet's surface that are less than four meters across.

The Deep Impact science team continues to probe the data collected during the Independence Day encounter, data that will provide new insight into comets. These beautiful, icy remnants of the ancient solar system provide clues to its formation and evolution and the role comets may have played in providing ancient Earth with water and other chemicals necessary for life.

SPIRIT AND *OPPORTUNITY* TREK ON

Since successfully completing their three-month primary missions in April 2004, the Mars Exploration Rovers, *Spirit* and *Opportunity*, have explored ever farther from their landing sites as they study Mars' geology. Both rovers have worked in the harsh Martian environment much longer than anticipated and are in amazingly good shape for their age. Their unanticipated longevity has allowed both rovers to reach destinations beyond the original scope of their missions and to keep making discoveries in pursuit of NASA's Vision for Space Exploration. NASA plans to keep both rovers exploring through September 2006, taking advantage of their excellent mechanical health.

What a difference ten days make: The photo on the left shows a part of *Spirit* covered in a thick layer of red, Martian dust on March 5, 2005. Ten days later, dust-lifting winds had blown the part clean. The solar arrays, which also were blown clean, began collecting more power. (Photos: Cornell/NASA)

Autonomous operation, particularly on a planetary surface, is an important capability for future robotic exploration vehicles. *Opportunity* gave NASA scientists a chance to hone their creative skills when it unwittingly drove itself into a sand trap. Every effort to free itself worked *Opportunity* deeper into the soft sand until all six wheels were mired up to their rims. For five weeks, the rover team at the Jet Propulsion Laboratory planned their long-distance "roadside assistance," carefully devising and testing a strategy to extricate the rover from its trap. The team cheered on June 4 when *Opportunity* sent images indicating that it was back on firm ground—rolling free and ready to find more Martian marvels.

NEXT STOP, MARS!

On the morning of August 12, 2005, an Atlas V launch vehicle roared away from Cape Canaveral Air Force Station, Florida carrying NASA's two-ton Mars Reconnaissance Orbiter (also known as MRO) on its seven-month flight to Mars. Its ambitious mission is to collect data about the planet's geology, mineralogy, climate, and history and distribution of water. In addition to providing insight into the red planet's past and present, the data will improve scientists' understanding of planetary climate change, in general.

While other missions have shown that water once flowed across the surface of Mars, scientists still do not know whether water remained long enough to provide a habitat for life. MRO will zoom in for extreme close-up photography of the Martian surface, analyze minerals, and look for subsurface water. Along the way, the spacecraft will look for resources, including water, that could support future human exploration.

MRO carries six scientific instruments that will examine the surface, atmosphere, and subsurface in unprecedented detail from low orbit. The orbiter's high-resolution camera will reveal surface features as small as a dishwasher. NASA expects that together, the instruments will obtain several times more data about Mars than all previous Martian missions combined.

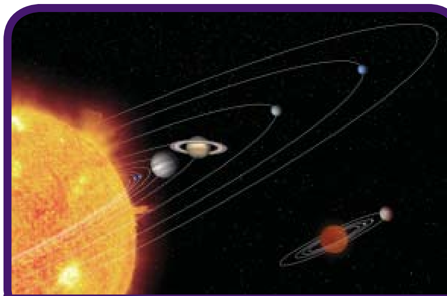
FINDING OTHER WORLDS

Human beings always have pondered the question, "Are we alone?" Medieval scholars speculated that other worlds must exist and that some would harbor other forms of life. In recent years, advances in science and technology have brought scientists to the threshold of finding an answer to this timeless question, and the recent discovery of numerous planets orbiting stars other than the Sun confirms that Earth's solar system is not unique. In fact, these "extra-solar planets" appear to be more common in the galaxy than ever expected, and with each discovery, scientists get a clearer understanding of the variety of planets in the universe and how and where Earth-like planets may form.

RED GIANTS REDEFINE THE SEARCH FOR EXTRA-TERRESTRIAL LIFE

Scientists recently discovered a new frontier in the search to find life outside the solar system: dying red giant stars may bring icy planets back from the dead. Once-frozen planets and moons may provide a breeding ground for life as their stars enter the last, and brightest, phase of their lives. Scientists hypothesize that when a Sun-like star expands into its red giant phase, it grows tremendously in size and brightness. Warm rays from the star reach out to a once-frozen and dead moon, and the solitary satellite's icy top layer quickly melts into liquid water that creeps across the surface and fills old craters with warmer seas. This sets the stage for the birth of new life in the moon's now-vibrant oceans. Previous ideas about the search for extra-solar life had excluded these regions, but an international team of astronomers now estimates that the emergence of new life on a planet is possible within the red giant phase.

One of the secrets of Earth's success in producing life is its location within the sphere of the Sun's "habitable zone." This donut-shaped boundary outlines where water can exist as a liquid in the solar system—a necessary component for the development of life. As the Sun develops into old age, its habitable zone will expand with it, changing the locales where liquid water—previously frozen as ice—can melt and provide a place where life may one day thrive. Lying just inside the outer limit of the Sun's habitable zone, Mars remains a frozen world because of its thin atmosphere. However, when the Sun becomes a red giant a few billion years from now, Mars may come alive. Currently, there are at least 150 red giant stars within 100 light years of Earth, and many of them may have orbiting planets capable of supporting life.



This artist's concept shows the relative size of a hypothetical brown dwarf-planetary system (lower right) compared to Earth's solar system. The Spitzer Space Telescope set its infrared eyes on an extraordinarily low-mass brown dwarf called OTS 44 and found a swirling disk of planet-building dust. At only 15 times the mass of Jupiter, OTS 44 is the smallest known brown dwarf to host a planet-forming, or protoplanetary, disk. (Image: NASA/JPL–Caltech/T. Pyle, SSC)

Spitzer spots mini-solar system

Moons circle planets, and planets circle stars. Now, with the help of NASA's Spitzer Space Telescope, astronomers believe that planets also may circle celestial bodies almost as small as planets.

This year, Spitzer continued to help scientists understand the complex and unusual circumstances under which Earth-like planets arise when it set its infrared eye on an extraordinary low-mass brown dwarf called OTS 44 and spotted a dusty swirling disk of planet-building material. A brown dwarf is a cool or "failed" star that lacks the mass to ignite and shine like the Sun. At only 15 times the mass of Jupiter, OTS 44 is the smallest known brown dwarf to host a planet-forming, or protoplanetary, disk.

Scientists believe that this unusual system eventually will spawn planets. If so, they speculate that OTS 44's disk has enough mass to make one small gas giant and a few Earth-sized rocky planets. In fact, scientists now believe that there may be a host of miniature solar systems in the universe.

Spitzer sees the light, sparks a new age of planetary science

This artist's concept shows what a fiery hot star and its close-knit planetary companion might look like close up if viewed in visible (left) and infrared light. In visible light, a star shines brilliantly, overwhelming the little light that is reflected by its planet. In infrared, a star is less blinding, and its planet perks up with a fiery glow. Astronomers using NASA's Spitzer Space Telescope took advantage of this fact to directly capture the infrared light of two previously detected planets orbiting outside our solar system. Their findings revealed the temperatures and orbits of the planets. (NASA/JPL–Caltech/R. Hurt, SSC)

When scientists search for planets outside the solar system, they do not try to spot the planet itself. Instead, they search for "wobble," the slight movement detected within distant starshine that indicates that the gravitational field of a planet is tugging on its parent star. Or, they search for a sign of "transit," the slight blip in the starshine that occurs when a planet passes in front of a star.

Thanks to the Spitzer Space Telescope, scientists have another way to spot an extrasolar planet. For the first time, Spitzer captured the light reflected off two known planets orbiting far-away stars. This marks a new age of planetary science in which extrasolar planets can be directly measured and compared.

According to two studies published in 2005, Spitzer directly observed the warm infrared glows of two previously detected "hot Jupiter" planets, designated HD 209458b and TrES-1. Hot Jupiters are distant gas giants that zip closely around their parent stars. From their orbits, they soak up enough starlight to shine in infrared wavelengths. To distinguish the planets' glow from that of their fiery host stars, the scientists used Spitzer to collect the total infrared light from both the stars and planets. Then, when the planets dipped behind the stars as part of their orbits, researchers measured the infrared

This artist's concept shows the planet catalogued as 2003UB313 at the lonely outer fringes of Earth's solar system. The Sun can be seen as a pale glow in the distance. The new planet, which awaits naming by the International Astronomical Union, is at least as big as Pluto and about three times farther away from the Sun than Pluto. (Image: NASA/JPL–Caltech)

light coming from just the stars. This pinpointed exactly how much infrared light belonged to the planets.

Adding another planet to the bunch

Scientists announced on July 29, 2005, that they found another planet at the outer region of Earth's solar system.

The research team, which included Mike Brown of the California Institute of Technology, Chad Trujillo of the Gemini Observatory at Mauna Kea, Hawaii, and David Rabinowitz of Yale University, in Connecticut, first spotted the distant object with the Samuel Oschin Telescope at Palomar Observatory in 2003. However, the object was so far away that its motion, and its true planetary nature, went unnoticed until the team reanalyzed the data in January 2005. After they realized what they had found, they restudied the planet for a better estimate of its size and motions.

The planet is a typical member of the Kuiper belt, which is populated by a multitude of small, rocky bodies. But, the newly discovered planet is much larger. "Even if it reflected 100 percent of the light reaching it, it would still be as big as Pluto," said Brown. "I'd say it's probably one and a half times the size of Pluto, but we're not sure yet of the final size."

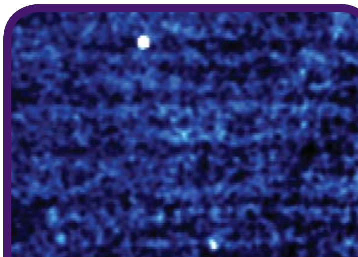
What the team does know for certain is that the planet is about 97 times farther from the Sun than Earth, making it the farthest-known object in the solar system. It also is the third brightest of the Kuiper belt objects.

The team has submitted a name for the new planet to the International Astronomical Union, which is responsible for selecting the names of planets, stars, and small bodies like comets.

SPITZER FINDS INGREDIENTS FOR LIFE IN THE DISTANT PAST

With the help of the Spitzer Space Telescope, scientists have detected organic molecules in galaxies dating back to a time when the universe was young. These large, complex molecules, known as polycyclic aromatic hydrocarbons, are made up of carbon and hydrogen and are considered by scientists to be among the building blocks of life. They are common on Earth and form any time carbon-based materials are not burned completely. They are found in sooty exhaust from cars and in charcoal-broiled hamburgers and burnt toast. They are pervasive in galaxies like the Milky Way, playing a significant role in star and planet building. However, Spitzer is the first telescope to see these molecules so far back in time—when the universe was one-fourth of its current age of about 14 billion years.

"This is 10 billion years further back in time than we've seen them before," said Lin Yan of the Spitzer Science Center in California, lead author of a study on the subject published in the August 10, 2005, issue of Astrophysical Journal. Since Earth is only four-and-a-half billion years old, these organic molecules existed in the universe well before Earth and the solar system were formed. In fact, they may have been included in the seeds of the solar system.



Swift's Burst Alert Telescope captured these two gamma-ray bursts in December. This was the spacecraft's first image, called by the science team Swift's "first light." The bright source at the top of the image is Cygnus X-1, thought to be a stellar-size black hole orbiting a massive star. The bright source at the bottom of the image is the lower-energy Cygnus X-3, a neutron star binary system enveloped in a cocoon of swirling dust and gas. (Image: NASA)

ERUPTIONS, BLACK HOLES, AND BURSTS

A look up at the night sky reveals an image of space that seems serene and quiet. This glimpse of the universe is deceptive. Space is filled with drama: creation, struggles, explosions, and death. As NASA's observation spacecraft watch, the dynamic universe is brought to Earth.

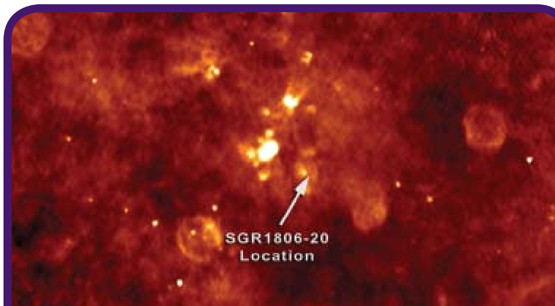
The birth of a black hole marks the start of a mission

On November 15, 2004, NASA launched the Swift spacecraft to observe gamma-ray bursts, the most powerful explosions the universe has seen since the Big Bang. Less than a month later, Swift observed three bursts in one day while the research team was still calibrating the main instrument, the Burst Alert Telescope. The bursts, which lasted less than a minute, likely signaled the birth of a black hole in Cygnus X-1, a bright source that produces gamma-ray bursts in the Milky Way galaxy. The team believes that the black hole formed in orbit around a star.

Swift is the first spacecraft dedicated to studying, and discovering the source of, gamma-ray bursts. It is a multi-wavelength observatory carrying instruments that can view the universe in the X-ray, ultraviolet, and optical ranges. Its Burst Alert Telescope is the most sensitive telescope ever flown in its particular spectral band. Even with these extra capabilities, the Swift team only expected to spot a couple of bursts per week, not three in one day. Researchers agreed: this is going to be an exciting mission.

Cosmic explosion outshines the Moon, spurs debate

Later in December 2004, the universe put on another light show—a flash of light from across the galaxy so powerful that it bounced off the Moon and lit up Earth's upper atmosphere. The flash, a "giant flare" from an exotic, magnetically powered neutron star called a magnetar, was more intense than anything ever detected from beyond this solar system. Lasting over a tenth of a second, the flare caught the "eye" of Swift, NASA's RHESSI spacecraft, and many ground-based radio telescopes.



An arrow points to SGR 1806-20, a magnetar that created a flash so bright it lit up the Moon, in this radio wavelength, wide-field image taken by a radio telescope at the University of Hawaii. The magnetar itself is not visible in the image, which was taken when SGR 1806-20 was "radio quiet." (Image: Univ. of Hawaii)

The light was the brightest in the gamma-ray energy range, far more energetic than visible light or X-rays and invisible to the human eye. Such a close and powerful eruption raised the question of whether an even larger burst of gamma rays disturbed Earth's atmosphere, causing one of Earth's mass extinctions hundreds of millions of years ago. Also, if giant flares can be this powerful, then some gamma-ray bursts, originally thought to come only from very distant black hole-forming star explosions, actually could be from neutron star eruptions in nearby galaxies.

A neutron star is the core that remains of a star that was once several times more massive than the Sun. When these stars use up their nuclear fuel, they explode in an event called a supernova. The remaining core is dense, like the mass of the Sun mashed down to a ball about 15 miles in diameter, fast spinning, and highly magnetic. Millions of neutron stars fill the Milky Way galaxy. Of these, scientists have discovered only about a dozen ultra-high-magnetic magnetars. The December 2004 flare, which originated in the vicinity of the constellation Sagittarius, produced more energy than the Sun emits in 150,000 years.

Four of the identified magnetars are called soft gamma repeaters because they flare up randomly and release low-energy gamma rays. In the 1980s, a scientific debate raged over the source of gamma-ray bursts, but by the 1990s, data indicated that gamma-ray bursts originate very far away as neutron stars explode and that soft gamma repeaters form differently. The December 2004 event reopened the debate. From this event, scientists determined that short gamma-ray bursts could come from soft gamma-ray repeaters up to 100 million light years from Earth. Long gamma-ray bursts appear to be from black hole-forming star explosions billions of light years away.

Gamma-ray-burst mystery revisited—and solved?

In May 2005, NASA scientists, for the first time, detected and pinned down the location of a short gamma-ray burst lasting only 50 milliseconds. Scientists finally may have the data they need to solve the mystery behind short gamma-ray bursts.

The burst was likely the result of a collision between two black holes or neutron stars, forming a new black hole. Despite how violent this sounds, theory predicts that such collisions produce short afterglows because they have little fuel—dust and gas—either from the colliding objects or the surrounding area to feed on. The burst appears to have originated only about 2.7 billion light years from Earth, supporting the theory that short gamma-ray bursts come from older, evolved neutron stars and black holes relatively close to home.

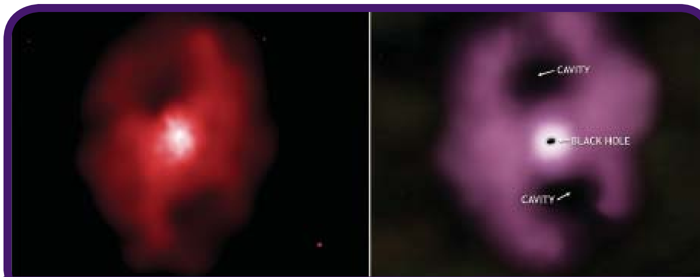
The afterglow of a burst contains the information scientists need to figure out what caused a burst. Before Swift was launched, short bursts were too fast for detailed observation. Swift's X-ray telescope detected a weak afterglow that faded away after about five minutes. Its ultraviolet/optical telescope saw nothing. Ground-based telescopes did not detect the afterglow. In contrast, afterglows from long bursts linger from days to weeks, providing ample opportunity to study them with a variety of telescopes.

Mystery solved? It is too soon for scientists to say, but thanks to Swift and other observing spacecraft, the answer likely will come soon.

Supermassive monster gone wild: a black hole story

While scientists puzzled over a flashy magnetar in the Milky Way galaxy, a supermassive black hole in a distant galaxy cluster called MS 0735.6+7421 asserted itself as the most powerful eruption in the universe.

On January 5, 2005, NASA's Chandra X-ray Observatory spotted hot, X-ray-emitting gas caused by a gravitational energy release as a supermassive black hole sucked down the equivalent mass of about 300 million Suns from a surrounding galaxy cluster. Most of the matter was swallowed, but some of it was ejected before being captured by the black hole. The resulting eruption, which has lasted for more than 100 million years, has generated the energy equivalent to hundreds of millions of gamma-ray bursts.



This image shows the Chandra X-ray image of the galaxy cluster MS 0735.6+7421 (left) in context with a labeled illustration of the system. The two giant cavities (dark red regions), found in the X-ray-emitting, hot gas (bright red) in the galaxy cluster, are evidence of the massive eruption. A supermassive black hole at the center of the bright X-ray emission caused the eruption. (X-ray image: NASA/CXC/Ohio U./B.McNamara et al.; Illustration: NASA/CXC/M.Weiss)

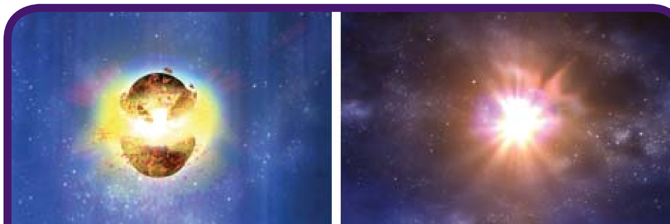
Scientists are not sure where such large amounts of matter came from. One theory is that gas from the host galaxy cluster cooled catastrophically and was swallowed by the black hole. The energy released shows the black hole has grown dramatically during the eruption. Previous studies suggest that other black holes have grown very little in the recent past and that only smaller black holes are still growing quickly.

"This new result is as surprising as it is exciting," said Paul Nulsen, scientist at the Harvard–Smithsonian Center for Astrophysics in Cambridge, Massachusetts, and co-author of the study about the discovery, published in the January 6, 2005, issue of Nature. "This black hole is feasting, when it should be fasting."

Ending the fiscal year with a really big (and far away) burst

Swift ended FY 2005 by spotting the most distant explosion yet, a gamma-ray burst from the edge of the visible universe. The September 4 burst, which likely marked the death of a massive star as it collapsed into a black hole, originated about 13 billion light years from Earth—back in an era soon after stars and galaxies first formed, about 500 million to one billion years after the Big Bang.

Scientists have spotted only one other object, a quasar, at a greater distance. However, quasars are supermassive black holes containing the mass of billions of stars, whereas a gamma-ray burst comes from a single star. Scientists now are studying how a single star could generate so much energy as to be seen from across the universe.



In this artist's concept, two neutron stars collide in a black-hole-forming explosion that was seen by Swift as a short gamma-ray burst. While black holes do not have a surface, they are regions in space of infinite density. The bursts marking their birth are extremely bright, but short lived, since they do not contain enough fuel to sustain a long afterglow. Swift was designed to spot these ephemeral explosions. (Image: D. Berry/NASA)

Swift was the first, but not the only, instrument watching this unusual burst. Swift detected the burst, called GRB 050904, and relayed its coordinates around the world within minutes. Scientists on four continents eagerly tracked the burst and its afterglow as it gradually faded over several days. The community heralded the discovery as a major breakthrough in the study of the early universe. Despite exhaustive searches, scientists have spotted relatively few quasars or other phenomena from the distant, ancient reaches of the universe. Based on Swift's numerous discoveries since its launch in 2004, scientists hope that gamma-ray bursts, including very distant bursts, are plentiful. If so, Swift will be the premier way to study the early universe.

VOYAGER FINDS SURPRISES IN THE SOLAR SYSTEM'S FINAL FRONTIER

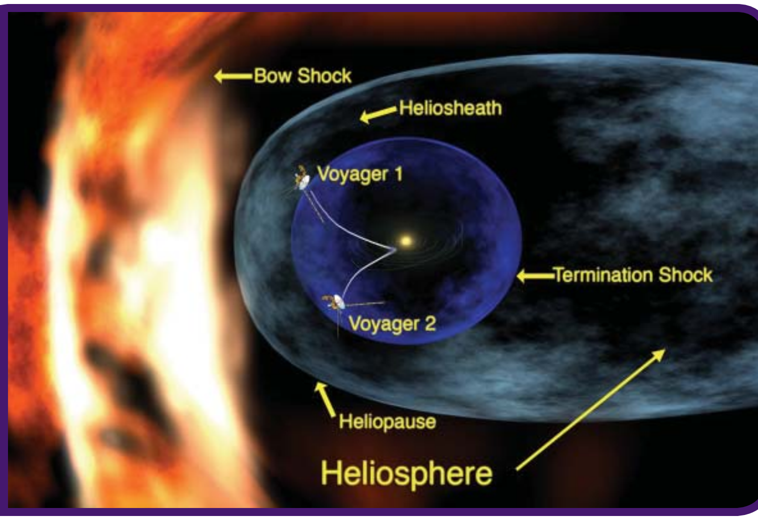
The solar system is surrounded by a bubble-shaped area called the termination shock, where the solar wind, a thin stream of electrically charged gas blowing continuously outward from the Sun, is slowed by pressure from gas outside the solar system. Voyager 1, which started its journey more than 26 years ago by investigating Jupiter and Saturn, burst through that bubble in May 2005 and entered into the solar system's final frontier.

Voyager is now flying through an area beyond the termination shock known as the heliosheath, a region created by the interstellar winds that blow past the protective shell of the solar system's heliosphere. During the spacecraft's trip through the edge of the solar system, it found some surprises that revealed new information about the Sun and its interaction with the rest of the galaxy.

Scientists expected the solar wind beyond the termination shock would slow down. But Voyager sent back data that said the speed was much slower than expected, and at times the solar wind appeared to be flowing back inward toward the Sun. Researchers believe this could be related to the highs and lows of the Sun's 11-year cycle of sunspot activity.

Perhaps the most puzzling surprise is what Voyager did not find at the shock. Scientists predicted that interstellar ions would bounce back and forth across the termination shock, slowly gaining energy with each bounce to become high-speed cosmic rays. Because of this, scientists expected those cosmic ray ions would become most intense at the shock. However, the intensity of the cosmic rays has steadily increased as Voyager moves farther beyond the shock. This means that the source of those cosmic rays is in a region of the outer solar system yet to be discovered.

As Voyager leaves the solar system, it ventures into new territory—interstellar space—that has only been glimpsed by telescopes. The spacecraft, which could survive the dark, cold reaches of space until 2020, will continue to make amazing discoveries.



This artist's concept depicts the two Voyager spacecrafts approaching the edge of the solar system, called the heliopause, where the Sun's influence ends. In spring 2005, Voyager 1 left the termination shock, where the million-mile-per-hour solar wind abruptly slows and becomes denser and hotter as it presses against interstellar gas, creating a bow shock. By the end of FY 2005, its sibling, Voyager 2, was traveling through the termination shock. (Image: NASA/Walt Feimer)

MEASURING NASA'S PERFORMANCE

Confronting the challenge of measuring performance

NASA faces a number of unique challenges in measuring and reporting annually on Agency performance. For example, NASA's goals are long term, and much of the Agency's work focuses on unpredictable discovery and innovation. Many NASA activities involve work that has never been done before, technology that has not been developed yet, and programs and projects that involve complex, high-risk research and development work. These challenges make it difficult for the Agency to take a valid annual measurement of performance progress. In fact, in some years, the NASA team might take a step back only to achieve greater performance progress in succeeding years. It is a management challenge of enormous proportion.

NASA's strategy for establishing, measuring, and achieving performance goals is simple: an integrated process that links budget planning and investment strategy with performance planning, tracking, and reporting. NASA is proud to be the first agency in the federal government that integrated strategic, budget, and performance planning processes and documents and used full-cost budgeting/accounting to identify the true costs for evaluating investment alternatives.

The current NASA Strategic Plan was updated in 2003; it is being rewritten for publication in 2006. The new Strategic Plan will reflect this integrated strategic planning and management system and it will underpin NASA's integrated planning process. This integrated planning process will create a framework that enables the Agency to measure performance on a continual basis and make necessary adjustments to ensure that programmatic and institutional performance goals are achieved.

Program Assessment Rating Tool

The Program Assessment Rating Tool (PART) is an evaluation tool developed by the Office of Management and Budget (OMB) to assess the effectiveness of federal programs. The PART assessment is rigorous and interactive. NASA submits one-third of its program portfolios to OMB each year, resulting in a complete Agency-wide assessment every three years.

An analysis of NASA's PART assessments shows that NASA consistently scores high for program purpose and design, strategic planning, and program management. Scores vary by program for results and accountability, with the science programs demonstrating the greatest results. (For a list of OMB's assessment of NASA's program portfolios, see Appendix 1.)

The President's Management Agenda

NASA tracked six initiatives under the President's Management Agenda (PMA) umbrella this fiscal year: Strategic Management of Human Capital; Competitive Sourcing; E-Government; Budget and Performance Integration; Real Property; and Financial Performance. By the end of FY 2005, NASA was on track to maintain or achieve "Green" status ratings in the first four initiatives, a "Yellow" status rating in Real Property, and a "Red" status rating in Financial Performance.

Following are NASA's FY 2005 PMA accomplishments:

- The Office of Personnel Management included a number of NASA human capital activities in their Best Management Practices Showcase.
- Other agencies use NASA's integrated budget and performance document, released as the annual Budget Estimates, as a benchmark for their own integrated budget and performance documents.
- The full-cost budget request for each program now includes its share of all costs, so the Agency can track the full cost of programs and manage them accordingly.
- Other agencies are benefiting from NASA's achievements in E-Government, as the Agency actively participates in inter-agency activities and lessons-learned-sharing.
- This year, NASA also is on track to receive a "green" in Competitive Sourcing (also referred to as A-76), having completed all major goals. Most important, NASA selected a provider for NASA's Shared Services Center initiative.
- Real Property is the newest PMA initiative to be tracked, and by June 30, NASA had completed all required actions to achieve a "Yellow" status rating. In addition, NASA's progress in upgrading its standing was rated "Green."

NASA remains “Red” in the Financial Performance initiative. Under the watchful eye of NASA’s Inspector General, however, NASA is working with OMB and the Agency’s other stakeholders to move forward in resolving material weaknesses in this area.

SUMMARY OF NASA'S FY 2005 PERFORMANCE RATINGS

In February 2005, NASA published *The New Age of Exploration: NASA's Direction for 2005 and Beyond*. This document provided the Agency's first strategic framework supporting the Vision for Space Exploration by identifying 18 long-term Strategic Objectives that NASA would pursue and to which all Agency program and resources would be tied.

In FY 2005, NASA directed the Agency's efforts toward achieving 14 of these Objectives. NASA revised the FY 2005 Performance Plan to reflect these Objectives and identified or developed Annual Peformance Goals (APGs) supporting each of the 14. However, since the Agency did not pursue Objectives 1, 9, 10, and 16 in FY 2005, they are not reflected in the rating summaries that follow or in the Detailed Performance Data in Part 2. NASA's intention is to address Objectives 1, 9, 10, and 16 in FY 2006 and beyond, although the format and wording of all 18 Objectives is subject to change, since NASA is developing a new Strategic Plan for publication in February 2006.

NASA's Objectives for FY 2005

2. Conduct robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration.
3. Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore Jupiter's moons, asteroids, and other bodies to search for evidence of life, to understand the history of the solar system, and to search for resources.
4. Conduct advanced telescope searches for Earth-like planets and habitable environments around the stars.
5. Explore the universe to understand its origin, structure, evolution, and destiny.
6. Return the Space Shuttle to flight and focus its use on completion of the International Space Station, complete assembly of the ISS, and retire the Space Shuttle in 2010, following completion of its role in ISS assembly. Conduct ISS activities consistent with U.S. obligations to ISS partners.
7. Develop a new crew exploration vehicle to provide crew transportation for missions beyond low Earth orbit. First test flight to be by the end of this decade, with operational capability for human exploration no later than 2014.
8. Focus research and use of the ISS on supporting space exploration goals, with emphasis on understanding how the space environment affects human health and capabilities, and developing countermeasures.
11. Develop and demonstrate power generation, propulsion, life support, and other key capabilities required to support more distant, more capable, and/or longer duration human and robotic exploration of Mars and other destinations.
12. Provide advanced aeronautical technologies to meet the challenges of next generation systems in aviation, for civilian and scientific purposes, in our atmosphere and in atmospheres of other worlds.
13. Use NASA missions and other activities to inspire and motivate the Nation's students and teachers, to engage and educate the public, and to advance the scientific and technological capabilities of the Nation.
14. Advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities including those with the potential to improve future operational systems.
15. Explore the Sun–Earth system to understand the Sun and its effects on Earth, the solar system, and the space environmental conditions that will be experienced by human explorers, and demonstrate technologies that can improve future operational systems.
17. Pursue commercial opportunities for providing transportation and other services supporting International Space Station and exploration missions beyond Earth orbit. Separate to the maximum extent practical crew from cargo.
18. Use U.S. commercial space capabilities and services to fulfill NASA requirements to the maximum extent practical and continue to involve, or increase the involvement of, the U.S. private sector in design and development of space systems.

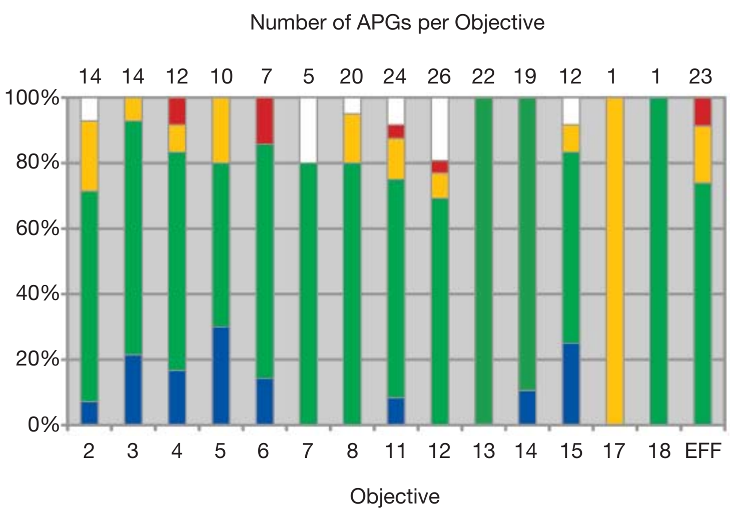
APG Rating Scale

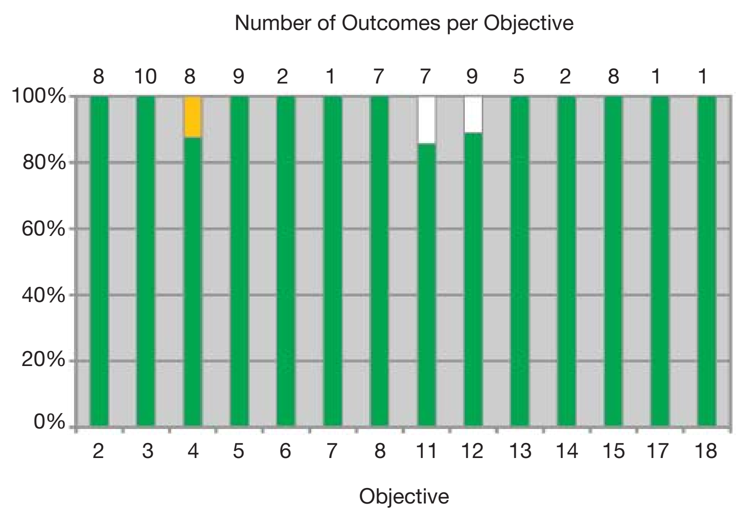
Blue	Significantly exceeded the APG.
Green	Achieved the APG.
Yellow	Failed to achieve the APG, but NASA made significant progress and anticipates achieving the APG next fiscal year.
Red	Failed to achieve the APG, and NASA does not anticipate completing it within the next fiscal year.
White	This APG was postponed or canceled by management directive.

Outcome Rating Scale

Green	Achieved most APGs; on track to achieve or exceed this Outcome.
Yellow	Progress toward the Outcome was significant, however, NASA may not achieve this Outcome as stated.
Red	Failed to achieve most APGs, and NASA does not expect to achieve this Outcome as stated.
White	This Outcome was postponed or canceled by management directive or this Outcome is no longer applicable based on management changes to the APGs.

In FY 2005, NASA achieved (rated Green) or exceeded (rated Blue) 82 percent of the Agency's 210 APGs. NASA did not achieve fully, but made significant progress toward achieving (rated Yellow), another 10 percent of the Agency's APGs. The remaining 8 percent either were not achieved (rated Red) or were not pursued due to management decisions (rated White). See the figure below, left, for a summary of NASA's APG ratings for FY 2005. NASA also is on track to achieve or exceed 96 percent of its 78 multi-year Outcomes. See the figure below, right, for a summary of NASA's Outcome ratings for FY 2005.





Part 2 of this report includes detailed performance data supporting the Performance Achievement Highlights, including color ratings and trend information, where applicable, for each APG and Outcome. Part 2 is organized by the Agency's Objectives and Outcomes as specified in NASA's FY 2005 Performance Plan Update. Part 2 also includes a detailed Performance Improvement Plan that describes the corrective actions necessary for NASA to achieve fully the APGs that were not achieved as planned this fiscal year.

The performance information in this report reflects data available as of September 30, 2005, unless otherwise noted.

NASA PERFORMANCE ACHIEVEMENT SCORECARD

Below is the score card rating showing NASA's progress toward achieving its 78 multi-year Outcomes during FY 2005. For detailed information about this fiscal year's performance, including NASA's Performance Improvement Plan, ratings for NASA's Annual Performance Goals, and rating trends, please see Part 2: Detailed Performance Data. (Please note that some Agency Objectives, and their associated Outcomes, are commitments for future budget years, and thus are not shown here.)

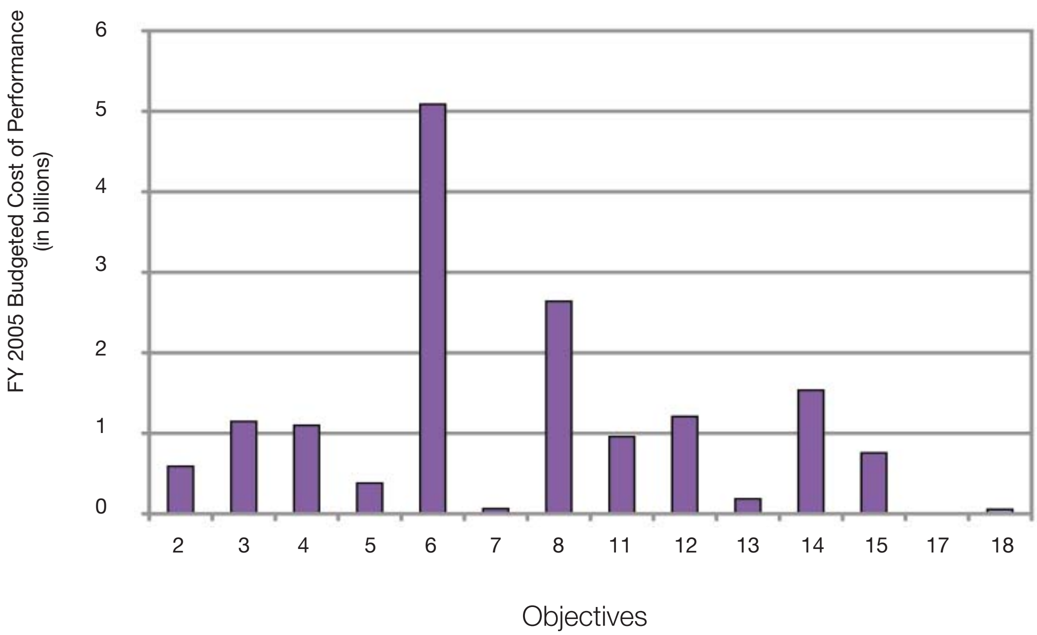
FY 2005 Outcome	FY 2005 Rating
2.1: Characterize the present climate of Mars and determine how it has evolved over time.	Green
2.2: Understand the history and behavior of water and other volatiles on Mars.	Green
2.3: Understand the chemistry, mineralogy, and chronology of Martian materials.	Green
2.4: Determine the characteristics and dynamics of the interior of Mars.	Green
2.5: Understand the character and extent of prebiotic chemistry on Mars.	Green
2.6: Search for chemical and biological signatures of past and present life on Mars.	Green
2.7: Identify and understand the hazards that the Martian environment will present to human explorers.	Green
2.8: Inventory and characterize Martian resources of potential benefit to human exploration of Mars.	Green
3.1: Understand the initial stages of planet and satellite formation.	Green
3.2: Understand the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact.	Green
3.3: Understand why the terrestrial planets are so different from one another.	Green
3.4: Learn what our solar system can tell us about extra-solar planetary systems.	Green
3.5: Determine the nature, history, and distribution of volatile and organic compounds in the solar system.	Green
3.6: Identify the habitable zones in the solar system.	Green
3.7: Identify the sources of simple chemicals that contribute to pre-biotic evolution and the emergence of life.	Green
3.8: Study Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere.	Green
3.9: By 2008, inventory at least 90 percent of asteroids and comets larger than one kilometer in diameter that could come near Earth.	Green
3.10: Determine the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth.	Green
4.1: Learn how the cosmic web of matter organized into the first stars and galaxies and how these evolved into the stars and galaxies we see today.	Green
4.2: Understand how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life.	Green
4.3: Learn how gas and dust become stars and planets.	Green
4.4: Observe planetary systems around other stars and compare their architectures and evolution with our own.	Green
4.5: Characterize the giant planets orbiting other stars.	Green
4.6: Find out how common Earth-like planets are and see if any might be habitable.	Green
4.7: Trace the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life.	Yellow
4.8: Develop the tools and techniques to search for life on planets beyond our solar system.	Green
5.1: Search for gravitational waves from the earliest moments of the Big Bang.	Green
5.2: Determine the size, shape, and matter–energy content of the universe.	Green
5.3: Measure the cosmic evolution of dark energy.	Green

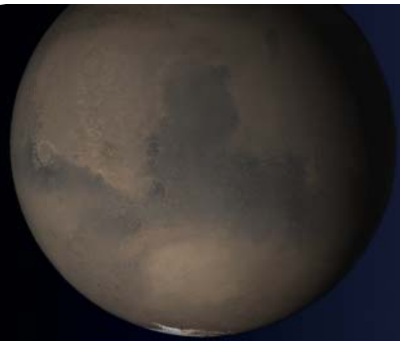
FY 2005 Outcome	FY 2005 Rating
5.4: Determine how black holes are formed, where they are, and how they evolve.	Green
5.5: Test Einstein's theory of gravity and map space–time near event horizons of black holes.	Green
5.6: Observe stars and other material plunging into black holes.	Green
5.7: Determine how, where, and when the chemical elements were made, and trace the flows of energy and magnetic fields that exchange them between stars, dust, and gas.	Green
5.8: Explore the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays.	Green
5.9: Discover how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies.	Green
6.1: Assure public, flight crew, and workforce safety for all Space Shuttle operations, and safely meet the manifest and flight rate commitment through completion of Space Station assembly.	Green
6.2: Provide safe, well-managed, and 95 percent reliable space communications, rocket propulsion testing, and launch services to meet Agency requirements.	Green
7.1: By 2014, develop and flight-demonstrate a human exploration vehicle that supports safe, affordable, and effective transportation and life support for human crews traveling from Earth to destinations beyond LEO.	Green
8.1: By 2010, complete assembly of the ISS, including U.S. components that support U.S. space exploration goals and those provided by foreign partners.	Green
8.2: Annually provide 90 percent of the optimal on-orbit resources available to support research, including power, data, crew time, logistics, and accommodations.	Green
8.4: By 2006, each Research Partnership Center will establish at least one new partnership with a major NASA R&D program to conduct dual-use research that benefits NASA, industry, and academia.	Green
8.5: By 2008, develop and test the following candidate countermeasures to ensure the health of humans traveling in space: bisphosphonates, potassium citrate, and mitodrine.	Green
8.6: By 2008, reduce the uncertainties in estimating radiation risks by one-half.	Green
8.7: By 2010, identify and test technologies to reduce total mass requirements for life support by two thirds using current ISS mass requirement baseline.	Green
8.8: By 2008, develop a predictive model and prototype systems to double improvements in radiation shielding efficiency.	Green
11.3: By 2015, identify, develop, and validate human–robotic capabilities required to support human–robotic lunar missions.	Green
11.4: By 2015, identify and execute a research and development program to develop technologies critical to support human–robotic lunar missions.	Green
11.5: By 2016, develop and demonstrate in-space nuclear fission-based power and propulsion systems that can be integrated into future human and robotic exploration missions.	White
11.6: Develop and deliver one new critical technology every two years in each of the following disciplines: in-space computing, space communications and networking, sensor technology, modular systems, robotics, power, and propulsion.	Green
11.7: Promote and develop innovative technology partnerships, involving each of NASA's major R&D programs, among NASA, U.S. industry, and other sectors for the benefit of Mission Directorate needs.	Green
11.8: Annually facilitate the award of venture capital funds or Phase III contracts to no less than two percent of NASA-sponsored Small Business Innovation Research Phase II firms to further develop or produce their technology for industry and government agencies.	Green
11.10: By 2005, demonstrate two prototype systems that prove the feasibility of resilient systems to mitigate risks in key NASA mission domains. Feasibility will be demonstrated by reconfigurability of avionics, sensors, and system performance parameters.	Green
12.1: By 2005, research, develop, and transfer technologies that would enable the reduction of the aviation fatal accident rate by 50 percent from the FY 1991–1996 average.	Green
12.2: Develop and validate technologies (by 2009) that would enable a 35 percent reduction in the vulnerabilities of the National Airspace System (as compared to the 2003 air transportation system).	Green

FY 2005 Outcome	FY 2005 Rating
12.3: Develop and validate technologies that would enable a 10-decibel reduction in aviation noise (from the level of 1997 subsonic aircraft) by 2009.	Green
12.4: By 2010, flight demonstrate an aircraft that produces no CO_2 or NOx to reduce smog and lower atmospheric ozone.	White
12.5: By 2005, develop, demonstrate, and transfer key enabling capabilities for a small aircraft transportation system.	Green
12.6: Develop and validate technologies (by 2009) that would enable a doubling of the capacity of the National Airspace Systems (from the 1997 NASA utilization).	Green
12.9: Develop technologies that would enable solar powered vehicles to serve as "sub-orbital satellites" for science missions.	Green
12.10: By 2008, develop and demonstrate technologies required for routine Unmanned Aerial Vehicle operations in the National Airspace System above 18,000 feet for High-Altitude, Long-Endurance (HALE) UAVs.	Green
12.11: Reduce the effects of sonic boom levels to permit overland supersonic flight in normal operations.	Green
13.1: Make available NASA-unique strategies, tools, content, and resources supporting the K–12 education community's efforts to increase student interest and academic achievement in science, technology, engineering, and mathematics disciplines.	Green
13.2: Attract and prepare students for NASA-related careers, and enhance the research competitiveness of the Nation's colleges and universities by providing opportunities for faculty and university-based research.	Green
13.3: Attract and prepare underrepresented and underserved students for NASA-related careers, and enhance competitiveness of minority-serving institutions by providing opportunities for faculty and university- and college-based research.	Green
13.4: Develop and deploy technology applications, products, services, and infrastructure that would enhance the educational process for formal and informal education.	Green
13.5: Establish the forum for informal education community efforts to inspire the next generation of explorers and make available NASA-unique strategies, tools, content, and resources to enhance their capacity to engage in science, technology, engineering, and mathematics education.	Green
14.3: Develop and implement an information systems architecture that facilitates distribution and use of Earth science data.	Green
14.4: Use space-based observations to improve understanding and prediction of Earth system variability and change for climate, weather, and natural hazards.	Green
15.1: Develop the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect Earth.	Green
15.2: Specify and enable prediction of changes to Earth's radiation environment, ionosphere, and upper atmosphere.	Green
15.3: Understand the role of solar variability in driving space climate and global change in Earth's atmosphere.	Green
15.4: Understand the structure and dynamics of the Sun and solar wind and the origins of magnetic variability.	Green
15.5: Determine the evolution of the heliosphere and its interaction with the galaxy.	Green
15.6: Understand the response of magnetospheres and atmospheres to external and internal drivers.	Green
15.7: Discover how magnetic fields are created and evolve and how charged particles are accelerated.	Green
15.8: Understand the coupling across multiple scale lengths and its generality in plasma systems.	Green
17.1: By 2010, provide 80 percent of optimal ISS up-mass, down-mass, and crew availability using non-Shuttle crew and cargo services.	Green
18.1: On an annual basis, develop an average of at least five new agreements per NASA Field Center with the Nation's industrial and other sectors for transfer out of NASA developed technology.	Green

NASA'S BUDGETED COST OF PERFORMANCE

NASA continually strives to enhance how the Agency reports on performance and the cost of that performance with the goal of being able to report costs of performance by Objective, Outcome, and APG. Due to the continuing issues with financial data previously reported, NASA cannot provide this level of cost information for FY 2005. However, as an interim measure, the FY 2005 budgeted cost of performance is included in this report for each Objective. These figures do not represent the actual cost of achieving NASA's Objectives; they reflect NASA's budgeted cost of performance, dollars allocated to achieving each NASA Objective. The figure below provides the budgeted cost of performance for the entire Agency. Additional detail is available, by Objective, in Part 2 of this report.





FY 2005 Financial Summary

FY 2005 FINANCIAL STATEMENTS SUMMARY

NASA is committed to ensuring that all stakeholders understand how NASA uses the Agency's resources to support NASA's mission effectively and efficiently. To do this, NASA relies on a single, integrated financial system to provide decision-makers with the accurate, reliable, and accessible data they need to manage their portfolio of projects and programs.

NASA's financial statements were prepared to report the financial position and results of the Agency's operations in accordance with generally accepted accounting principles as defined by The Chief Financial Officer's Act of 1990. These financial statements were prepared from NASA's Integrated Financial Management System Core Financial Module and other Treasury reports in accordance with formats prescribed by the Office of Management and Budget. They are in addition to financial reports prepared from the same books and records used to monitor and control budgetary resources. The statements should be read with the realization that NASA is a component of the U.S. Government, a sovereign entity.

Assets, Liabilities, and Cumulative Results of Operations

The Consolidated Balance Sheet reflects total assets of $46.3 billion and liabilities of $3.5 billion for FY 2005. Unfunded liabilities reported in the statements cannot be liquidated without legislation that provides resources to do so. About 75 percent of the assets are property, plant, and equipment (PP&E), with a book value of $34.9 billion. PP&E is property located at NASA's Centers, in space, and in the custody of contractors.

Cumulative Results of Operations represents the public's investment in NASA, akin to stockholder's equity in private industry. The public's investment in NASA is valued at $37.5 billion. The Agency's $42.8 net position includes $5.3 billion of unexpended appropriations (undelivered orders and unobligated amounts or funds provided, but not yet spent). Net position is presented on both the Consolidated Balance Sheet and the Consolidated Statement of Changes in Net Position.

Net Cost of Operation

The Statement of Net Cost shows the net cost of NASA's operations for FY 2005 (i.e., the amount of money NASA spent to carry out programs funded by Congressional appropriations).

Improper Payments

In compliance with the Improper Payments Information Act of 2002 and specific guidance from the Office of Management and Budget, NASA developed a systematic process for reviewing all programs that are susceptible to significant improper payments. All NASA Centers were tasked to perform a statistical sampling of payments to determine the rate, volume, and amount of payments that were made improperly. Based on the review, NASA examined 883 payments representing $82,542,704. The results of the examination indicated that 18 payments were made improperly. Those payments represented an error rate of 2.1 percent and amounted to $617,442.

Since NASA's FY 2005 performance was better than the Office of Management and Budget error rate threshold of 2.5 percent or greater and total improper payments of $10,000,000 or more, NASA is not at risk for significant improper payments. The Agency's low rate of improper payments is due in large part to improved internal controls. In December 2004, NASA awarded a recovery audit contract to Horn and Associates, Inc., to assist in identifying and recouping erroneous payments.

MANAGEMENT AND FINANCIAL SYSTEMS, CONTROLS, AND LEGAL COMPLIANCE

This report satisfies the legislative requirements that NASA address the systems and internal controls in place to ensure management excellence, accountability, and Agency compliance with applicable laws, statutes, and regulations. NASA identifies issues of concern through a strong network of oversight councils and internal and external auditors including NASA's Operations Council, the Office of Inspector General, the General Accountability Office, the Office of Management and Budget, the NASA Advisory Council, and the Aerospace Safety Advisory Panel. In addition, NASA uses various systems to ensure effective management, including NASA's Online Directives Information System (used to communicate applicable policy and procedural requirements Agency-wide), NASA's Corrective Action Tracking System (used to track audit follow-up actions), and Erasmus (used by executive management to review program and project performance).

NASA is in compliance with all relevant laws, statutes, and legislation, unless otherwise noted and explained.

Statement of Reliability and Completeness of Financial and Performance Data: Audit Results

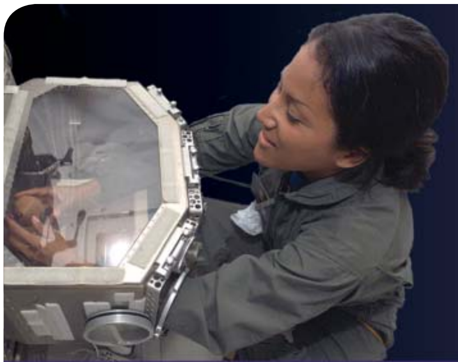
NASA accepts the responsibility of reporting performance and financial data accurately and reliably with the same vigor as we accept and conduct our scientific research.

All performance data for this report is gathered and reported through a system of rigorous controls and quality checks. Representatives from each Mission Directorate gather year-end performance data from their respective program and project officers. The Associate Administrators of each Mission Directorate review and validate the data. Analysts in the Office of the Chief Financial Officer also review the data before it is archived with all pertinent source information. In addition, NASA uses its Erasmus management information system to track and report on performance, schedule, and financial data on a regular basis.

NASA conducted all financial operations using Integrated Financial Management System Core Financial Module at all NASA Centers. The system is certified by the Joint Financial Management Improvement Program and provides a consistent operating environment and improved internal controls.

The financial statements are prepared from the Agency's accounting books and records, and the financial data contained in this report was subjected to a comprehensive review process to evaluate its accuracy and reliability. While the Integrated Financial Management System Core Financial Module has improved NASA's financial management processes, NASA has a few remaining challenges related to the system start-up and data conversion issues. As with the implementation of any new system, critical transactional data must be identified, validated, documented and converted—and conversion errors are likely to occur. NASA deployed dedicated resources throughout the Agency to analyze and reconcile data differences. As the fiscal year ended, NASA made significant corrective progress, but there remain some unresolved data issues. Consequently, NASA was unsuccessful in fully resolving the data issues that resulted from the system conversion, and the independent auditors were unable to render an opinion on our FY 2005 financial statements; they issued a disclaimer of opinion.

Therefore, for FY 2005, NASA can provide reasonable assurance that the performance data in this report is complete and reliable. Performance data limitations are documented explicitly. However, the Agency cannot provide reasonable assurance that the financial data in this report is complete and reliable.



Legislative Requirements, OMB Guidelines, and Internal Controls

NASA's annual Performance and Accountability Report satisfies a number of executive, legislative, and regulatory reporting requirements, including those of the *Government Performance and Results Act* of 1993, the *Chief Financial Officers Act* of 1990, and the *Reports Consolidation Act* of 2000.

NASA is in compliance with all Performance and Accountability Report requirements. The table below lists the legislative acts and other regulations that mandate specific Performance and Accountability Report content requirements, the specific nature of those requirements, and where in this report the compliant information and statements can be found.

Statutes and Office of Management and Budget Guidelines	Requirement	Comments
Chief Financial Officers Act of 1990	Submit an audit report concerning financial management along with a financial statement of the preceding year.	NASA's financial statements and the report of NASA's Independent Auditors can be found in Part 3: Financials.
E-Government Act of 2002	Provide details on the resources utilized for information technology security at government agencies.	NASA maintains an ongoing information technology security program that meets federal requirements. The OMB 2007 Budget submission includes expenditures of approximately $90 million in FY 2007, this ongoing program includes activities related to information technology security management, operations, and maintenance.
Federal Financial Management Improvement Act (FFMIA) of 1996	Submit an annual statement concerning the implementation and compliance with accounting and financial guidelines.	The FFMIA statement is included in Part 1: Message from the Administrator.
Federal Managers Financial Integrity Act of 1982 (FMFIA)	Provide a report on the health and integrity of an agency's financial, programmatic, and institutional activities and their ability to safeguard against waste, loss, unauthorized use, or misappropriation of funds.	The FMFIA statement is included in Part 1: Message from the Administrator.
Government Performance and Results Act of 1993	Provide information on an agency's annual performance and progress in achieving the goals in its strategic plan and performance budget.	Parts 1 and 2 of this report meet the requirement for an annual performance report.
Inspector General Act of 1978, as amended	The Inspector General of the agency will provide a summary of serious management challenges.	Appendix 2 contains NASA's Inspector General's report on serious management challenges. The follow-up audit actions are included in Appendix 3.

Statutes and Office of Management and Budget Guidelines	Requirement	Comments
Office of Management and Budget Circular A-136: Financial Reporting Requirements	Agencies shall prepare PARs in accordance with OMB Bulletin No. 01-09 Form and Content of Agency Financial Statements, as amended, and OMB Circular No. A-11 Preparation, Submission, and Execution of the Budget, as amended.	Part 3 of this report, containing NASA's financial statements, is prepared in accordance with OMB guidance and regulations.
	Agencies shall submit their PARs to OMB and the Congress no later than 45 days after the end of the fiscal year.	Because NASA's fiscal year ends September 30, the Agency submits its Performance and Accountability Report to OMB and Congress no later than November 15.
Office of Management and Budget Bulletin 01-09: Form and Content of Agency Financial Statements (OMB Circular A-136, above, supercedes this bulletin)	For performance and accountability reports, agencies are encouraged to include in a single location a summary discussion of performance that meets both MD&A and GPRA performance report requirements. Agencies should include a statement by the agency head regarding the completeness and reliability of the financial and performance data.	Part 1: Message from the Administrator provides the statement of reliability and completeness. Part 3 includes an additional statement and overview from NASA's Chief Financial Officer.
	The MD&A should include comparisons of the current year to the prior year and should provide an analysis of the agency's overall financial position and results of operations to assist users in assessing whether that financial position has improved or deteriorated as a result of the year's activities.	Part 1: Financial Summary includes management's discussion of NASA's overall financial position. Part 3 provides a more detailed overview of NASA's finances and provides a commparison of current and prior year(s) financial position where available or appropriate.
	An agency's financial statements should include basic statements and related notes, required supplementary stewardship information, and required supplementary information.	Part 3 of this report contains NASA's financial statements and all related notes and information.

Statutes and Office of Management and Budget Guidelines	Requirement	Comments
Office of Management and Budget Circular A-11: Preparation, Submission and Execution of the Budget	Provide a comparison of actual performance with planned performance as set out in the agency's annual performance plan.	NASA provides a comparison of actual versus planned performance by Objective, Outcome, and Annual Performance Goal in Part 2: Detailed Performance Data. Part 2 also includes narrative discussion of multi-year Outcomes.
	Provide an explanation, where a performance goal was not achieved, for why the goal was not met, descriptions of the plans and schedules to meet unmet goals in the future, or alternatively, actions regarding unmet goals that are deemed impractical or infeasible to achieve.	See NASA's Performance Improvement Plan in Part 2: Detailed Performance Data.
	Evaluate your performance budget for the current fiscal year, taking into account the actual performance achieved.	Beginning in FY 2006, NASA is evaluating and modifying its strategy and performance system to enable the Agency to better use performance data for budget planning purposes.
	Provide actual performance information for at least four fiscal years.	Performance ratings under each Outcome in Part 2: Detailed Performance Data provide performance trend information (when applicable) for the last four fiscal years.
	Provide Program Assessment Rating Tool (PART) Assessments.	Appendix 1 contains a summary of OMB's PART recommendations for NASA programs.
Office of Management and Budget Circular A-123: Management's Responsibility for Internal Control	Provide annual Statement of Assurance signed by the Administrator on the effectiveness of internal control.	Following Part 1: Letter from the Administrator is an insert, signed by the Administrator, entitled Management Assurances. It contains the overall Statement of Assurance on all internal control matters, followed by the Statement of Assurance for Internal Control Over Financial Reporting. The first statement fulfills the Section 2 requirement of FMFIA and the second statement addresses Section 4 of FMFIA.
	A-123 includes reporting requirements for the Clinger–Cohen Act of 1996, Single Audit Act, as amended, the Improper Payments Information Act of 2002 (IPIA), and the Federal Information Security Management Act of 2002 (FISMA).	NASA's Chief Financial Officer and Office of Inspector General agreed to implement the new requirements in the FY 2006 Performance and Accountability Report.
Reports Consolidation Act of 2000	Combine an agency's performance report with its accountability report.	This report represents the combination of NASA's performance and accountability reports.
	Each performance report shall contain an assessment of the completeness and reliability of the financial and performance data used in the report.	The assessment of completeness and reliability is included in Part 1: Message from the Administrator.
	Include Office of Inspector General serious management challenges.	Serious management challenges are referenced in Part 1: Message from the Administrator and provided in full in Appendix 2.