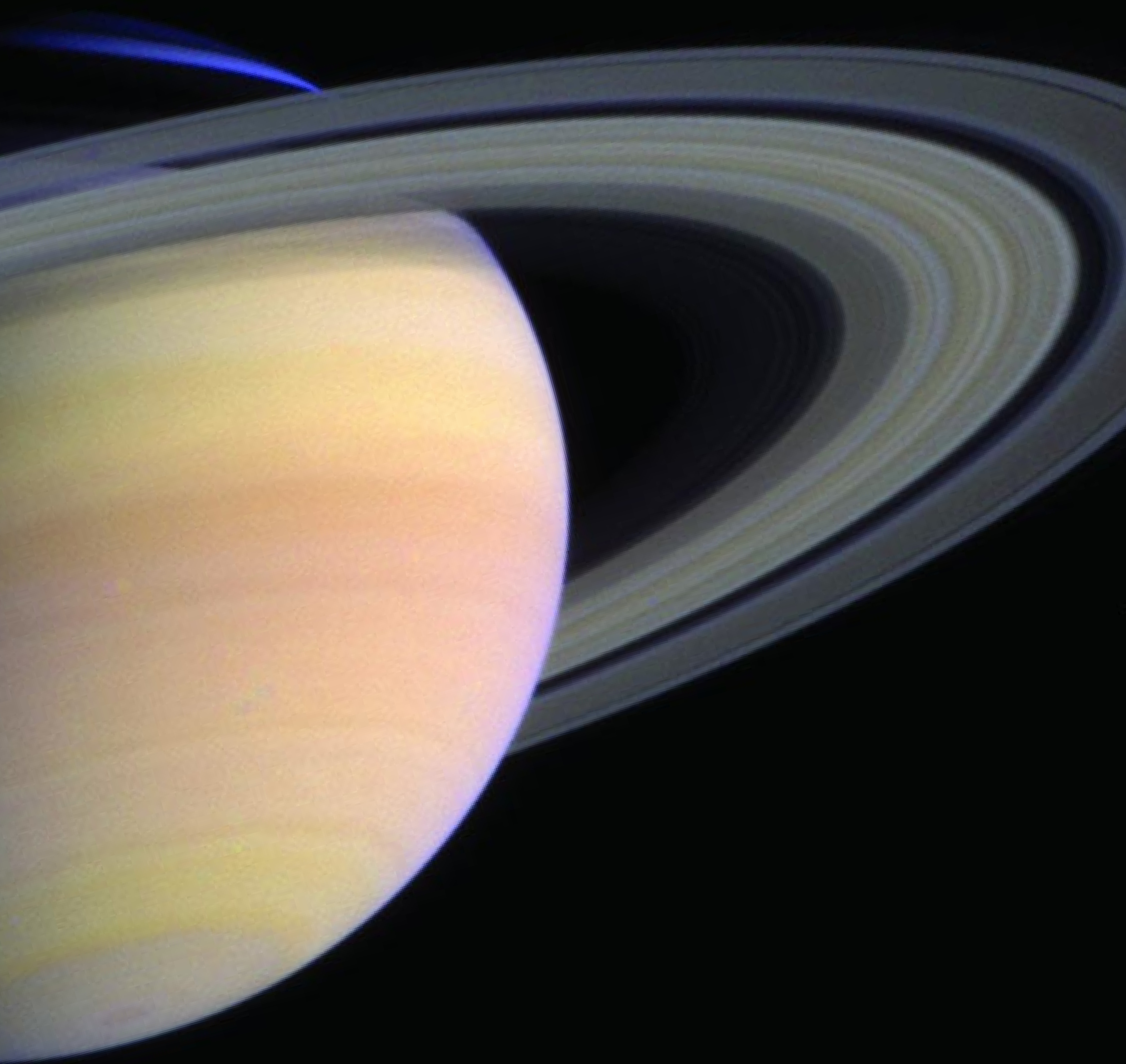


National Aeronautics and Space Administration

Fiscal Year 2004

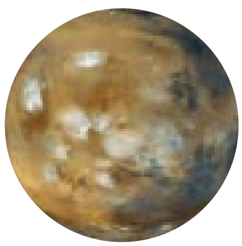
Performance and Accountability Report

Introduction to NASA's Performance and Accountability Report

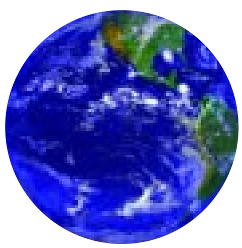
This is the National Aeronautics and Space Administration's (NASA) *Fiscal Year 2004* (FY 2004) *Performance and Accountability Report*. It is a detailed account of NASA's performance in achieving its annual goals and long-term objectives for its programs, management, and budget. It includes detailed performance information and financial statements as well as management challenges and NASA's plans and efforts to overcome them.

The 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:

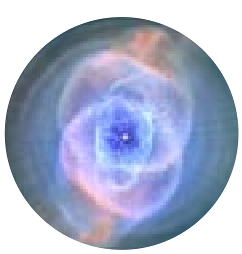


Part 1—Management Discussion and Analysis. Part 1 presents a snapshot of NASA's FY 2004 performance achievements. It focuses on the tools, capabilities, and accomplishments that make NASA the Nation's premier research and development agency for aeronautics and space. Part 1 also addresses financial and 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 five 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 Strategic Plan and the FY 2004 Performance Plan. Part 2 also describes the actions that NASA will take in the future to achieve goals that have not been met in FY 2004.

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



Appendices. The Appendices include The Office of Inspector General Summary of Serious Management Challenges and audit follow up reports required by the *Inspector General Act*.

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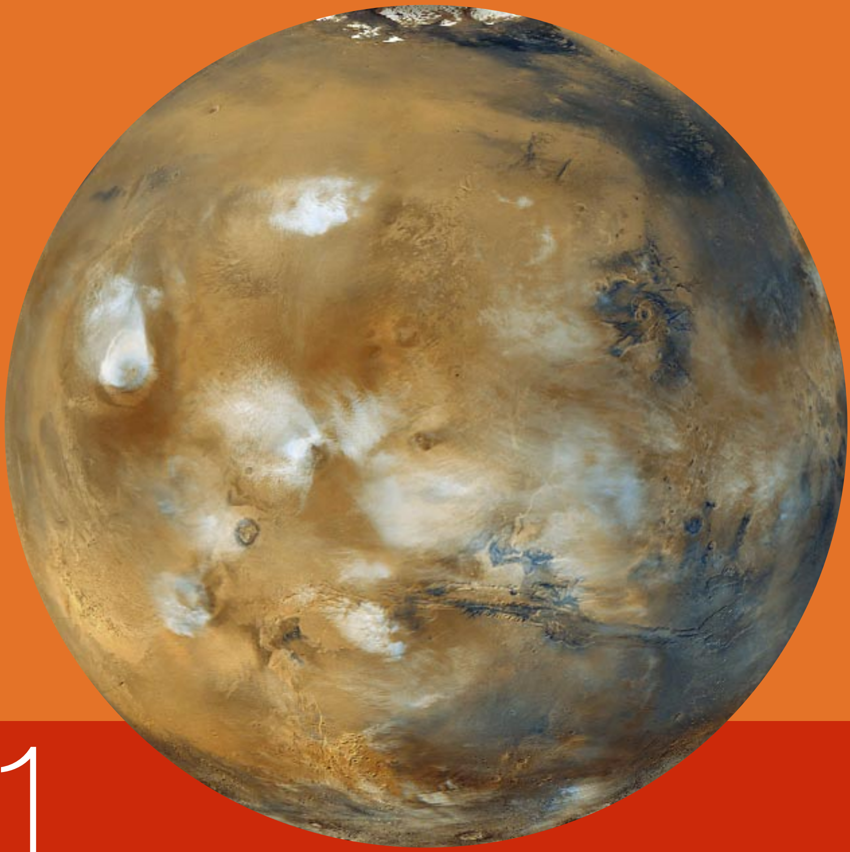
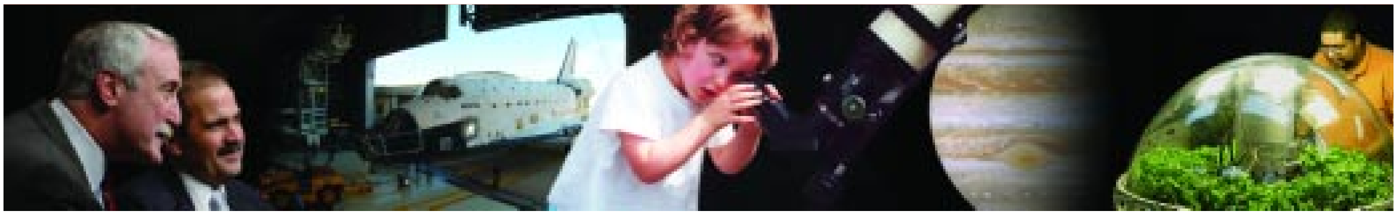


Part 1

Management Discussion and Analysis

Message from the Administrator



In tribute to the NASA family, past, present, and future, I am pleased to submit the *FY 2004 NASA Performance and Accountability Report.*

NASA began FY 2004 energetically engaged in fulfilling our promise to honor the fallen crew of *Columbia* by: complying with all of the recommendations of the *Columbia* Accident Investigation Board; raising the safety bar higher than ever for all NASA missions, operations, and ground activities; and returning the Space Shuttle to flight as soon as humanly and safely possible. Then, just three months into the new fiscal year, our present and future changed dramatically.

A Renewed Spirit of Discovery: The President's Vision for U.S. Space Exploration

On January 14, 2004, during a visit to NASA Headquarters in Washington, D.C., President George W. Bush announced a new vision for the Nation's space exploration program. In his remarks, the President stated:

> *Inspired by all that has come before, and guided by clear objectives, today we set a new course for America's space program. We will give NASA a new focus and vision for future exploration. We will build new ships to carry man forward into the universe, to gain a new foothold on the moon, and to prepare for new journeys to worlds beyond our own.*

At the same time, President Bush established the President's Commission on Implementation of the U.S. Space Exploration Policy, chaired by former Under Secretary of Defense and Secretary of the Air Force Edward C. "Pete" Aldridge, Jr. In June 2004, the Aldridge Commission presented its findings and recommendations to the President. Previous plans for FY 2004 were melded into new plans for FY 2004 and beyond, and the entire Agency set out on a bold new path to the future.

The fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program. In support of this goal, the United States will:

- Implement a sustained and affordable human and robotic program to explore the solar system and beyond;
- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and
- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

President George W. Bush
A Renewed Spirit of Discovery:
The President's Vision for U.S. Space Exploration

NASA'S Transformation: Moving Toward "One NASA"

In June 2004, the Aldridge Commission gave NASA recommendations to help the Agency implement the goals of the new Vision for Space Exploration. In its report, the Aldridge Commission recommended that NASA "…be transformed to become more focused and effectively integrated to implement the national space exploration vision, with a structure that affixes clear authority and accountability." The Commission asserted that a transformed NASA should do the following:

- Create positive organizational and cultural change within NASA so the Agency can focus work on effectively carrying out long-term exploration goals;

- Replenish our talent and technology base with a new generation of scientists, engineers, and explorers; and
- Leverage our capabilities with the support of partner organizations and private sector innovation.

NASA's transformation is off to a strong start. We have established four Mission Directorates (Exploration Systems, Space Operations, Science, and Aeronautics Research) and restructured our 13 functional offices into eight Mission Support Offices, elevating the Office of Education and the Office of Safety and Mission Assurance to reflect Agency priorities and values. We defined NASA's strategic requirements, developed a means to identify core competencies, and adjusted the FY 2006 budget process to stress collaboration across Mission Directorates, programs, and Centers. We established the Strategic Planning Council and the Operations Council to improve our decision-making processes, and we added an Associate Deputy Administrator for System Integration and a Director of Advanced Planning to improve strategic and systems integration across NASA.

In response to one of the key recommendations in the Aldridge Commission report, an internal NASA team also began considering reconfiguration models for our Centers. The team is reviewing the Federally Funded Research and Development Center model, the Federal Government Corporation model, the University Affiliated Research Center model, and various institute and hybrid organizational models. Full consideration and implementation of possible changes will take place over the next several years since reconfiguring the Centers is a complex process.

NASA's transformation goes beyond an internal reorganization. "Reorganization" implies restructuring to perform the same operations more efficiently and effectively. While transforming NASA's organizational structure streamlines the Agency and positions us better to implement our Vision for Space Exploration, NASA's culture also plays a role in our transformation. Therefore, we are complying with the recommendations of the *Columbia* Accident Investigation Board and the Aldridge Commission to effect a positive, values-driven culture. To ensure our success in this aspect of NASA's transformation, the Agency's senior leaders revalidated NASA's core values: Safety; the NASA Family; Excellence; and Integrity. And, to foster a climate of openness and free-flowing communication, we are assessing our leadership practices and developing comprehensive individual leader action plans to improve our effectiveness at all levels of the organization.

By transforming NASA, we are promoting synergies across the Agency to support our new Vision for Space Exploration. We are streamlining our organization to clarify lines of authority and accountability. And, we are making good on our promise to the American people to understand and protect our home planet, to explore the universe and search for life, and to inspire the next generation of explorers as only NASA can.

FY 2004 Performance Highlights

NASA's performance goals for FY 2004 were ambitious. In support of our ten strategic goals, we focused on 42 long-term performance objectives and 132 performance outcomes while measuring our progress in 233 short-term Annual Performance Goals (APGs). By the end of the fiscal year, we had exceeded or fully achieved 85 percent of our APGs and made substantial progress in another six percent. We failed to make significant progress in only two percent of our APGs, and seven percent of our APGs were postponed or cancelled by management directive.

EXPLORATION

NASA ushered in the second century of flight by making outstanding strides in exploration. Among our achievements, we successfully landed the twin Mars Exploration Rovers, *Spirit* and *Opportunity*, on the Martian terrain and watched as they sent back wondrous images of the Red Planet. We partnered with the European Space Agency in a joint venture that led to the start of the Cassini–Huygens four-year exploration of Saturn and its moons. We launched NASA's MESSENGER spacecraft on its mission to explore and map the surface of Mercury. And, we launched Aura into the heavens to look back at Earth and give us a better picture of our atmosphere and changing climate.

Exploration of the heavens is a challenging and difficult task. We celebrate our successes, and we learn much from our failures. For example, the Genesis mission traveled far from Earth to gather clues to the origins of the universe, but its return to Earth was marred by a faulty landing. However, NASA scientists salvaged nearly all of the valuable science payload and we have learned from the landing mishap.

Figure 1: Dr. Don Burnett sorts through Genesis sample return material in a clean room at the Jet Propulsion Laboratory

RETURN TO FLIGHT

The new Vision for Space Exploration begins with safely returning the Space Shuttle to flight. Preparations for NASA's return to flight are proceeding well, and numerous system and vehicle enhancements will ensure that NASA has unprecedented safety inspection and detection capabilities when Space Shuttle *Discovery* lifts off in 2005.

With NASA's Space Flight Leadership Council overseeing return to flight activities, and the Stafford-Covey Return to Flight Task Group providing external oversight, we reached several key milestones in FY 2004 that moved us closer to a launch in 2005. We made more than 100 major maintenance modifications and upgrades to *Discovery* and its supporting systems, including new cabling and wiring that will support leading edge sensors, a digital camera, and a boom extension for the Shuttle's robotic arm that will enable us to inspect nearly all the outside areas of the orbiter's Thermal Protection System during missions. Technicians installed the Forward Reaction Control System and the Reinforced Carbon-Carbon Nose Cap, and 88 sensors are being installed on each wing; 66 will measure acceleration and impact data, and 22 will take temperature data during *Discovery's* journey. Overall, we are making substantial progress on the milestones toward a launch in 2005.

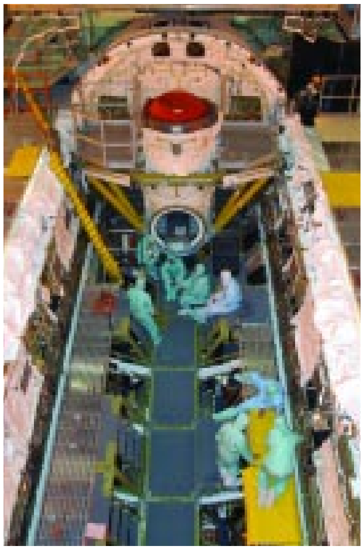


Figure 2: Crews install an orbiter Boom Sensor System in *Discovery's* bay on June 10, 2004. The OBSS, a new return to flight safety measure, includes cameras and laser systems attached to a long crane-like boom that can inspect the Shuttle's thermal Protection System during flight.

The President's Management Agenda

In April 2004, Office of Personnel Management Director Kay Coles James and Office of Management and Budget Deputy Director Clay Johnson, III, honored NASA for being the first Federal agency to achieve the highest standards (a "green" rating) in two of the President's Management Agenda (PMA) initiatives: Strategic Management of Human Capital and Budget and Performance Integration. As a result, a number of other Federal agencies benchmarked NASA's programs and initiatives, and Office of Personnel Management included a number of NASA activities in the June 2004 Office of Personnel Management Best Practices Showcase.

In FY 2004, NASA's human capital management accomplishments included:

- Passage of the *NASA Flexibility Act* of 2004 which provides NASA with new flexibilities to recruit and sustain a world-class workforce while adhering to merit principles, veterans' preference requirements, equal opportunity guidelines, and the rights of labor organizations. NASA began using the flexibilities after developing and implementing a workforce plan with valuable union and other stakeholder input and after disseminating information to our human resources professionals and managers on the appropriate uses of the flexibilities.
- Refinement of NASA's Competency Management System, a tool to assist us in identifying the competencies necessary for mission success, assessing competency strengths and weaknesses, and identifying "at risk" competencies. NASA used information from this system during FY 2004 campus recruiting events to make on-the-spot offers to highly qualified candidates.
- Initiation of activities to enhance NASA's culture change goals and change leadership behaviors in ways that reinforce NASA's commitment to safety and organizational excellence.
- Creation of a more integrated leadership development strategy. For example, we completed benchmarking activities in leadership development with other government, academic, and industry organizations, and we piloted several activities to expand mobility and rotational assignments.

NASA also was the first agency in the Federal government to receive a "green" rating in the PMA area of Budget and Performance Integration. We achieved this rating by fully integrating our budget, performance, and strategic planning processes and documents ensuring that all levels of the Agency are guided by a single strategic plan.

NASA's achievements in this PMA initiative included:

- Creating an Integrated Budget and Performance Document that ties the annual budget request to the annual Performance Plan. These are no longer two separate documents; performance commitments now appear alongside their related budget requests.
- Implementing full-cost budgeting. In previous budget requests, program budgets primarily contained contract funds while civil service salaries and overhead were held in a separate appropriation. Now, the budget request for each program includes its share of all costs so we know the full cost of programs and can manage accordingly.

In FY 2004, NASA also implemented Erasmus, a new management information system. Erasmus provides easy access to information on budget and performance to enhance informed decision-making.

Like the original PMA mascot, Kermit the Frog, NASA knows that it is "not easy being green," so getting a "green" rating in two PMA initiatives was a great achievement for the Agency. However, we also made excellent progress in two other PMA initiatives

Credit: NASA/R. Bouchard

Figure 3: In a ceremony held in April 13, 2004, Kay Coles James, Director of the Office of Personnel Management, presented NASA Administrator Sean O'Keefe with a Kermit the Frog doll (shown left) in recognition of NASA achieving a "green" rating for their progress in the PMA area of Human Capital. In turn, O'Keefe presented James with a plaque of appreciation from NASA.

(E-Government and Competitive Sourcing), and we anticipate getting "green" ratings in both by 2005. We also made progress in the remaining PMA initiative, Improved Financial Management.

- In the area of E-Government (E-Gov), we produced our first set of integrated plans for Information Technology (IT) management. The Agency improved management of IT investments by instituting a new IT Capital Planning and Investment Control process and by developing the Agency's first integrated Office Automation, Infrastructure, and Telecommunications case that analyzes general purpose IT investments needed to support NASA's missions. We are redesigning our IT security management approach and participating in government-wide E-Gov initiatives. For example, we are migrating our personnel and payroll systems to the Department of Interior.
- In the area of Competitive Sourcing, we created a dedicated Agency Competitive Sourcing Team to oversee competitive sourcing initiatives and a Competitive Sourcing Review Board and network to facilitate internal communication. NASA initiated two standard competitions, and we conducted nearly continuous public-private competitions to fund world-class, cost-effective scientific research. Pursuant to the *Federal Activities Inventory Reform Act*, NASA's 2004 inventory identifies 445 scientists and engineers engaged in NASA science projects as a result of winning competitions under NASA Research Announcements and Announcements of Opportunity.
- In the area of Improved Financial Management, we continue to fine-tune and benefit from NASA's newly implemented Integrated Financial Management System Core Financial Module (IFMS-CFM). This program standardizes financial data and processes across the Agency and replaces the 140 disparate financial systems previously in place. However, we also must resolve continuing problems related to the transition to our new system as described in detail below.

FY 2004 Financial Statements Summary

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 IFMS-CFM 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 $45.4 billion and liabilities of $3.7 billion for FY 2004. Unfunded liabilities reported in the statements cannot be liquidated without legislation that provides resources to do so. About 76 percent of the assets are property, plant, and equipment (PP&E), with a book value of $34.6 billion. PP&E is property located at NASA's Centers, in space, and in the custody of contractors.

Almost 75 percent of PP&E consists of assets held by NASA, while the remaining 25 percent is property in the custody of contractors. The book value of assets in space (i.e., various spacecraft operating above the atmosphere for exploration purposes), constitutes $18 billion, or 69 percent, of NASA-owned and -held PP&E.

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 $36.9 billion. The Agency's $41.7 billion net position includes $4.8 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 OPERATIONS

The Statement of Net Cost shows the net cost of NASA's operations for FY 2004 (i.e., the amount of money NASA spent to carry out programs funded by Congressional appropriations). As noted, in August 2004, NASA restructured and streamlined the organization by moving to four Mission Directorates. The statement of net cost is organized by each of the new Mission Directorates separately and presents the Space Flight Capabilities (Net Costs of $6.4 billion), and Science, Aeronautics, and Exploration (Net Costs of $8.6 billion) separately with all remaining items reported as costs not assigned (Net Costs of $1.5 billion).

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, 759 payments representing $14,655,922 were examined. The results of the examination indicated that fifteen payments were made improperly. Those payments amounted to $70,599 and an error rate of 2.0 percent.

Since NASA's FY 2004 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. Our low rate of improper payments is due in large part to improved internal controls. We are in the process of awarding a recovery audit contract to assist us 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, and a number of special external advisory bodies. In addition, NASA utilizes 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 Enterprise/Mission Directorate gather year-end performance data from their respective program and project officers. The Associate Administrators of each Enterprise/ 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 new Erasmus management information system to track and report on performance, schedule, and financial data on a regular basis.

Fiscal year 2004 marked the first year that NASA conducted all financial operations using IFMS-CFM at all NASA Centers. The new system is certified by the Joint Financial Management Improvement Program and provides a consistent operating environment and improved internal controls.

Our 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 new IFMS-CFM improved NASA's financial management processes during this first full year of operations, we experienced significant challenges with 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, we made significant corrective progress, but there remain some unresolved data issues. Consequently, we were 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 2004 financial statements; they issued a disclaimer of opinion.

Therefore, for FY 2004, I can provide reasonable assurance that the performance data in this report is complete and reliable. Performance data limitations are documented explicitly. However, I cannot provide reasonable assurance that the financial data in this report is complete and reliable.

FEDERAL FINANCIAL MANAGEMENT IMPROVEMENT ACT (FFMIA)

In accordance with the *Federal Financial Management Improvement Act* (FFMIA), our IFMS-CFM is able to produce 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 IFMS-CFM is transactional based, it does not record all transactions properly, at the account detail level required in the U.S. Standard General Ledger.

Because of the above conditions and some residual system security concerns, NASA's IFMS-CFM does not comply with the requirements of the *Federal Financial Management Improvement Act*. Significant progress has been made toward resolving the issues that prevented the system from being FFMIA compliant in FY 2004. In FY 2005, NASA will focus on bringing the system into compliance.

FEDERAL MANAGERS FINANCIAL INTEGRITY ACT (FMFIA) STATEMENT OF ASSURANCE

NASA submits a qualified Statement of Assurance for FY 2004 because we are reporting three material weaknesses. In response to recommendations of the NASA Operations Council, I have decided that one material weakness reported in FY 2003, Space Shuttle, should remain open as we project full return to flight no sooner than 2005. After the Space Shuttle returns safely to flight and all recommendations of the *Columbia* Accident Investigation Board are closed, this material weakness will be downgraded in magnitude for external reporting, but it will be tracked internally for prudent oversight.

For FY 2004, I also am adding two new material weaknesses: Financial Management and Contractor-Held Property and Materials.

CONTINUING MATERIAL WEAKNESSES

Space Shuttle

The Final Report of the *Columbia* Accident Investigation Board identified a number of systemic cultural, organizational, and managerial issues within the Space Shuttle program (and NASA as a whole) that contributed to the *Columbia* accident on February 1, 2003. The Board identified 15 "Return to Flight" and 14 long-term recommendations designed to address these issues. NASA's return to flight effort is guided by these recommendations, as well as by internal "raise the bar" actions identified by the Space Shuttle program.

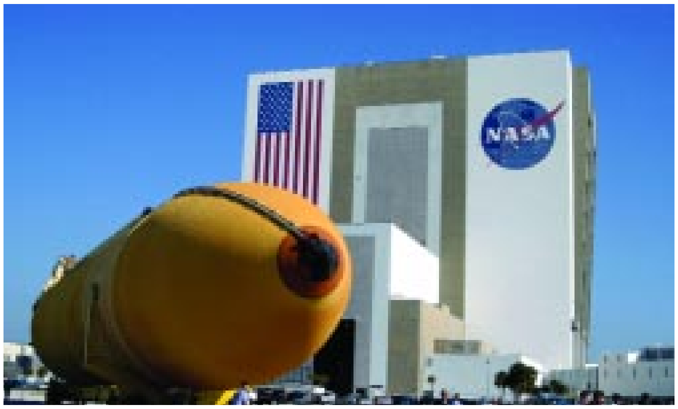


Figure 4: A Shuttle external tank was guided out of the Vehicle Assembly Building at Kennedy Space Center as it began its journey to the Michoud Space Systems Assembly Facility near New Orleans, Louisiana.

NASA continues to embrace the Board's report, accept the findings, and comply with the Board's recommendations. NASA's *Implementation Plan for Space Shuttle Return to Flight and Beyond* outlines the path that NASA will take to respond to the recommendations and safely return to flight. We will continue to update this document periodically to reflect changes to the plan and the progress we make toward implementation of the recommendations, and the Stafford-Covey Return to Flight Task Group will continue to review our actions. NASA will not return the Space Shuttle to flight until this Task Group determines that all recommendations have been addressed adequately. To date, the Space Shuttle program has closed five of these recommendations conditionally with the Stafford-Covey Task Group. We continue to make progress towards closing the remaining recommendations to achieve our goal of returning the Space Shuttle to flight in 2005.

NEW MATERIAL WEAKNESSES

Financial Management

In FY 2004, NASA is reporting a material weakness in its Financial Management based on two consecutive years of disclaimer issued by external auditors on the Agency's annual financial statements. NASA has not reconciled its Fund Balance With Treasury account balance to amounts reported by the Department of the Treasury. While NASA made progress toward correcting transactions related to the FY 2003 Fund Balance With Treasury adjustments to the accounting system, many Fund Balance With Treasury transactions remain unresolved. In addition, NASA also has not resolved all issues related to the accounting system conversion that took place in FY 2003.

During FY 2004, we updated and published financial management policies and procedures to standardize financial operations and practices throughout the Agency. We also published our annual financial statements from the IFMS-CFM one month before the required submission date of November 15, 2004.

During FY 2005, NASA will revise its long-range financial management improvement plan to reflect all critical tasks and to ensure financial data are accurate, timely, and reliable for Agency managers.

Contractor-Held Property and Materials

NASA has elevated the significance level of a major deficiency in contractor-held property and materials that was identified as a material weakness in the *FY 2002 Performance and Accountability Report*. In FY 2003, NASA downgraded this material weakness to an internally tracked “other” weakness because many actions had been taken to correct accountability and reporting on this weakness. In FY 2004, NASA continued to implement corrective actions, and we made measurable progress to mitigate this weakness, including publication of definitive policies and procedures to account for property in the possession of contractors. The Office of the Chief Financial Officer implemented a quality control program to assess our largest contractors’ compliance with Agency policies and procedures for validating and reporting NASA property and materials in their possession. NASA also conducted training on the updated policies and procedures for NASA employees and contractor staffs.

In FY 2005, NASA will implement an automated asset tracking system for contractor-held property to facilitate accounting and reporting. We also will continue to make process improvements to ensure that internal control of property is established and maintained effectively.

Looking Forward

The focus of NASA’s future is clear thanks to our new Vision for Space Exploration. Clear, too, are the current management and performance challenges we must confront and overcome to achieve this Vision as evidenced by the consistency in report findings and recommendations from the *Columbia* Accident Investigation Board, the Aldridge Commission, and our own Inspector General.

NASA is forging ahead to correct organizational and technical deficiencies that will enable us to function more efficiently and effectively as One NASA, return the Space Shuttle to flight, and continue assembly of the International Space Station. We are working to ensure that NASA’s Integrated Financial Management System improves the Agency’s ability to allocate costs to programs, provides reliable information to management, and supports NASA’s compliance with the *Chief Financial Officers Act* of 1990. And, we are continuing our efforts to enhance information technology security throughout the Agency by strengthening our internal controls.

NASA’s transformation will continue in the months ahead as we make changes to enhance our ability to implement the Vision for Space Exploration. We embrace these opportunities as only NASA can!

Sean O’Keefe
NASA Administrator

Extraordinary People, Remarkable Results: NASA's Exploration Heroes of 2004

In FY 2004, NASA continued to demonstrate that exploration is at the heart of the Agency's spirit and tradition.

- On the surface of Mars, the twin rovers, *Spirit* and *Opportunity*, made history with their extensive investigations of the Gusev Crater and Meridiani Planum sites. *Opportunity's* discovery that Meridiani was once subsumed under an ancient salty sea ranks among the top scientific discoveries of the year.
- NASA broke an important aviation barrier in March with the flight of the NASA X-43A airplane which used a scramjet engine to fly seven times the speed of sound. This scramjet technology eventually may provide the most efficient path from ground to space.
- The NASA-European Space Agency Cassini–Huygens mission began its four-year investigation of Saturn, including its rings, moons, and magnetosphere. The mission returned spectacular images and revealed two new Saturnian moons that may be the smallest bodies so far seen around the ringed planet.
- NASA's MESSENGER spacecraft launched on a mission to map the surface of Mercury.
- NASA launched the Aura spacecraft into orbit on a mission to investigate the dynamics of Earth's atmosphere. This launch completed the first series of NASA's Earth Observing System satellites.
- NASA's great observatories—the Hubble Space Telescope, Chandra X-Ray Observatory, and the Spitzer Infrared Space Telescope—continued to make important discoveries about distant reaches of the universe. For example, in August 2004, the Chandra X-Ray Observatory sent back a spectacular new image of the supernova remnant Cassiopeia with nearly 200 times more data than was seen in earlier images. The data suggests that Cassiopeia had a far more complicated origin than was originally believed.
- On board the International Space Station, crewmembers from Expeditions Seven, Eight, and Nine participated in experiments to better understand the effects of long-term space travel on human beings. The research results will help NASA prepare for the long-duration exploration missions ahead.

Certainly, NASA astronauts are the most visible and celebrated members of NASA's exploration team. Whether at work on the International Space Station, visiting NASA's Explorer Schools, or engaged in ground-based efforts in NASA laboratories and offices, they are recognizable heroes of space exploration. But, NASA relies on thousands of talented and dedicated scientists, engineers, and safety and support personnel behind the scenes to advance NASA's bold exploration objectives. From all of these extraordinary people, the Nation receives remarkable results.

The following stories about just a few members of the NASA family make it clear that NASA's performance in FY 2004 resulted from the hard work, ingenuity, and daring of some of the best Earth-based explorers our country has to offer.

Exploring the Red Planet: Jim Garvin's Martian Chronicles

When he was three years old, Dr. James (Jim) Garvin, NASA's Chief Scientist for Lunar and Martian Exploration and Deputy Exploration Chief Scientist, prepared well for his future role by "crawling around the backyard collecting rocks…." Even as a youth, his sights were set on distant worlds. Since Garvin lived in many places around the Middle East when he was growing up, he developed an early appreciation for desert landscapes, which he imagined to be the environments of other worlds. He recalls being "stunned" and "awed" by the Apollo 11 lunar landing mission in 1969.

Inspired by Professor Tim Mutch, the legendary planetary geologist and former NASA Associate Administrator, Garvin became a NASA intern in 1976 and helped with the Viking II landing mission on Mars. More recently, as a full-time NASA employee, one of his most

Credit: NASA/R. Bouchard

Figure 5: Jim Garvin has worked on Mars missions since his days as a NASA intern back in the 1970s.

important tasks was to help ensure that the mission to land two Mars Exploration Rovers on the Red Planet would obtain the best possible science return, as well as fit into a strategy that would help NASA search for evidence of life. To accomplish this objective, Garvin spear-headed a process by which scientists from around the world participated in a series of workshops that determined the landing targets: Gusev Crater and Meridiani Planum.

In January 2004, Jim Garvin was at NASA's Jet Propulsion Laboratory in Pasadena, California, with his colleagues to watch, tense and excited, as each rover came to an airbag-aided, bouncing, "soft" landing on Mars. He then marveled with millions of people throughout the world as *Spirit* and *Opportunity* set about their work of sending back to Earth remarkable images and compositional information about the Martian landscape.

In fact, Garvin lights up when asked to describe the accomplishments of the rovers, which have extended their scientific exploration work months beyond their expected three-month lifetime. "These rovers have accomplished three profound things," he says. "Number one, they have moved across the surface of Mars. They've given us a taste of what exploration will be like when humans get to Mars. Second, they have found for the first time, as definitively as we can without going there ourselves and bringing rocks back, that Mars had standing bodies of surface water that dried up like salty seas dry up here on Earth…. And that's an indicator we need to understand, as we ask, 'Was there life there?' The third thing they've done is given us a target for linking what we see on the surface at the rover sites to the Mars Reconnaissance Orbiter we are launching next year. So, we are going to look at the rover sites where we found these rocks and evidence of ancient seas, and extrapolate all across the planet to look for other places that might be even better science targets, where the record of those kinds of water-related rocks is more exposed. By the turn of the decade, we can then send sophisticated laboratories to these sites to ask [and perhaps answer] profound questions about the origins of life."

Exploring Saturn: Meet Robert Mitchell, Ringmaster

When he was growing up on a farm in Springville, Pennsylvania, Robert (Bob) Mitchell had no idea that he might one day help scientists harvest a wealth of knowledge about Saturn and its fascinating planetary environment. But, after studying electrical engineering and math, life lead him to the planetary exploration team working at NASA's Jet Propulsion Laboratory.

Early in his career, Mitchell worked on the trajectory design, mission design, and navigation for the Mariner 5 mission to Venus, the Mariner 6, 7, and 9 missions to Mars, and the Viking Mars landing project. NASA recognized his skills in dealing with all facets of complex planetary missions were recognized, and he was elevated

Credit: NASA/R. Bouchard

Figure 6: Robert Mitchell talks about the Cassini mission at a program held on June 3, 2004.

to Project Manager on the Galileo Jupiter mission, and then to Program Manager/Project Manager for the joint NASA/European Space Agency/Italian Space Agency Cassini-Huygens mission to Saturn. He is NASA's resident expert on the Cassini-Huygens mission, but he describes his work as being more akin to a diplomatic mission, making sure that disputes between eager scientists and more cautious engineers are amicably resolved.

On the evening of June 30, 2004, after guiding the project through six of its seven-year journey to Saturn, Mitchell says he experienced "white knuckle time" as the project team waited for a clear signal that Cassini-Huygens had successfully threaded the needle between Saturn's F and G rings and entered into orbit around the planet. "When the Doppler signal leveled out," signifying the orbital insertion was successful, "that was a big relief," he said.

Now, Mitchell looks forward to Cassini-Huygen's four-year exploration of the planet, its rings, moons, and magnetosphere. The mission's next big milestone will occur on January 14, 2005, when the Huygens probe will descend into the atmosphere of Saturn's mysterious moon, Titan, which has an atmosphere similar to Earth's billions of years ago. When that event happens, Bob Mitchell will be among those with white knuckles back in Pasadena, waiting for another epic story in the history of space exploration to unfold. “We’re still in the process of reviewing and scrubbing a number of things,” he says, “but we have every reason to believe that the Huygens descent will be just as successful as Saturn orbital insertion was.”

Exploring Extraordinary Opportunities: Robert Shelton’s Campaign to Make Math and Science Accessible

NASA math whiz and computer software designer Dr. Robert Shelton considers himself lucky even though he lost his sight when he was 11 years old. He feels lucky to have had parents and teachers who spotted his talent in mathematics and science, encouraged him, and provided tools that helped him pursue his interests.

Shelton was born with congenital glaucoma, a disease that was hard to cure in the 1950s when he was a child. After suffering through 40 operations, “It was almost a relief to lose my sight and have it over with. Before I lost my sight, I was a smart kid, but rather sloppy,” Shelton said. “My mother told me, ‘You’re going to have to use different muscles now—the ones between your ears.’ She was tough on me. She said I could do whatever I wanted, but I would have to work even harder because I was blind,” Shelton added.

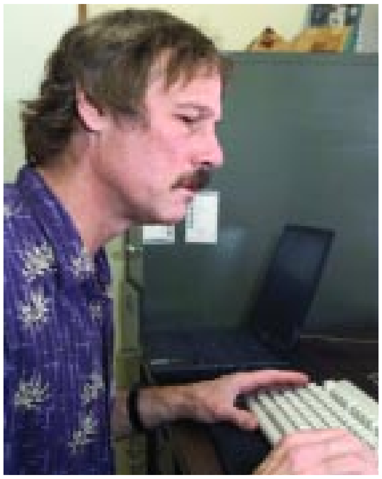


Figure 7: Robert Shelton, mathematician and computer programmer, works in his office at Johnson Space Center.

As a child in Houston, Shelton enjoyed working with his father, an electrical engineer, tinkering in the family garage, building things and tearing them apart to see how they worked. After losing his sight, he continued that trend in a different way—learning mathematical equations and scientific laws that explain why things work. His teachers helped him study advanced mathematics and science and taught him to visualize concepts in his mind.

After earning three degrees in mathematics at Rice University in Houston, Shelton worked as a graduate intern at NASA’s Johnson Space Center helping to design the navigation system for the Space Shuttle. And, when NASA offered him a job working on artificial intelligence systems, Shelton joined Johnson’s Software Technology Branch, designing computer technology used to analyze data sent from the Space Shuttle to the Mission Control Center in Houston.

Shelton also uses his math and computer expertise to head up the Johnson Space Center’s contributions to NASA’s Learning Technologies Project, creating technology tools for teachers and students in kindergarten through 12th grade. In January 2004, Shelton and his team delivered a prototype version of the Math Description Engine software, a graphing calculator that generates text descriptions and “sonifications,” or graphs rendered in sound as a sequence of tones. This tool then was enhanced for use at a summer camp for blind high school students held at the National Federation of the Blind Jernigan Institute in Baltimore, the Goddard Space Flight Center, and the Wallops Flight Facility. Shelton joined the team at the Goddard Space Flight Center to oversee the 2004 summer program and to conduct Explorer School workshops for teachers to help them identify techniques for making NASA science available to students with blindness or low vision.

Shelton believes that using NASA technology and know-how to reach people with disabilities is a natural match, and his leadership has ensured that NASA’s technology Web sites are accessible to students with disabilities. “I want blind and sighted students who use the site to find out what they can do,” Shelton said. “I want teachers to have easy-to-use, cutting-edge technology tools that make math and science accessible to all students. Most important, I want employers to emulate NASA by hiring blind people and using their talents,” he added.

Exploring Educational Challenges: Barbara Morgan and the Legacy of Lewis and Clark

On May 14, 1804, an exploration party known as the Corps of Discovery, led by Meriwether Lewis and William Clark, set out on boats from Camp Dubois on the east bank of the Mississippi River near St. Louis. Their mission was to scout the vast Louisiana Purchase lands President Thomas Jefferson had just obtained from France. Their adventures brought them to new lands and introduced them to new people. And, when they reached the Bitterroot River valley, in present-day Montana, a group of Native Americans known as the Salish Tribe warmly greeted them. The stage was set. Our young Nation’s first epic voyage and a tradition of exploration and discovery was underway.

Fast-forward 200 years to meet Barbara Morgan, a NASA astronaut who, 30 years ago, began her career in elementary education teaching reading and math to young members of the same Salish Tribe on the Flathead Reservation in Montana. These direct descendants of the people who greeted the Lewis and Clark expedition had no idea they were being taught by a person destined to join the ranks of America's explorers… and neither did their teacher.

Eleven years after her first teaching experience, Morgan joined hundreds of other teachers who applied for NASA's Teacher-in-Space program. "Teachers are always looking for opportunities to make learning more meaningful and engaging for our students so we can help them reach their own full potential," Morgan says when asked why she applied for the program. "To me, the NASA Teacher-in-Space program provided a perfect opportunity to gain experiences to become a better teacher and to connect our students directly to our wonderful universe."

Morgan was selected for the program and trained to be the backup for New Hampshire teacher Christa McAuliffe. When McAuliffe and her fellow Shuttle astronauts tragically died in the January

Figure 8: Educator-astronaut Barbara Morgan interacts with children in the classroom.

1986 *Challenger* disaster, Morgan resolved to continue McAuliffe's inspirational mission. In April 2002, NASA Administrator Sean O'Keefe announced that Morgan would finally get her space flight opportunity. Administrator O'Keefe added that on future missions, she and her "Educator Astronaut" colleagues would "have the full range of responsibilities that any other astronaut has," as well as the specific assignment of working to inspire and motivate a new generation of explorers.

As the Nation marked the 200th anniversary of the Lewis and Clark expedition, Barbara Morgan was preparing for her participation in STS-118, a flight to complete the construction of power generation and communications capabilities for the International Space Station. For her, the dream of space flight is alive and well. "Teachers know that kids learn by example," she says. "They learn by watching what adults do. Kids also pay attention to what adults decline to do. Going to the Moon and to Mars is a tremendous undertaking, involving many things that we don't know how to do yet. But, we know that we can learn how to do them. And students will watch us learn. They'll learn that learning itself is valuable, and that we as a Nation will always explore."

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 partners in other Federal agencies, the private sector, and academia, as well as with NASA's international partners and stakeholders, the Agency uses its unique skills and capabilities to continue the American tradition of exploration and pioneering. NASA's Vision statement and Mission statement reflect NASA's commitment to redefining what is possible for the benefit of all humankind.

NASA's Vision Statement:
To improve life here,
To extend life to there,
To find life beyond.

NASA's Mission Statement:
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers,
…as only NASA can.

NASA's Values

Values are essential to shaping the culture of an organization and guiding what is appropriate behavior in that organization. Having and promoting a set of core values gives all members of the organization a common basis for evaluating themselves and one another against established expectations. Therefore, to break down stove-piped organizational barriers and promote the philosophy of "One NASA," and to achieve the culture changes recommended in both the *Columbia* Accident Investigation Board Report and the Aldridge Commission Report, NASA began its 2004 transformation by taking a hard look at its values. During the Senior Leadership Council session held in May 2004, NASA's top managers carefully considered this issue, determined to identify and embrace core values that would support the work of the Agency as it transforms itself and embarks on the Vision for Space Exploration. The result was the revalidation of the values that have always reflected NASA's spirit, determination, and priorities:

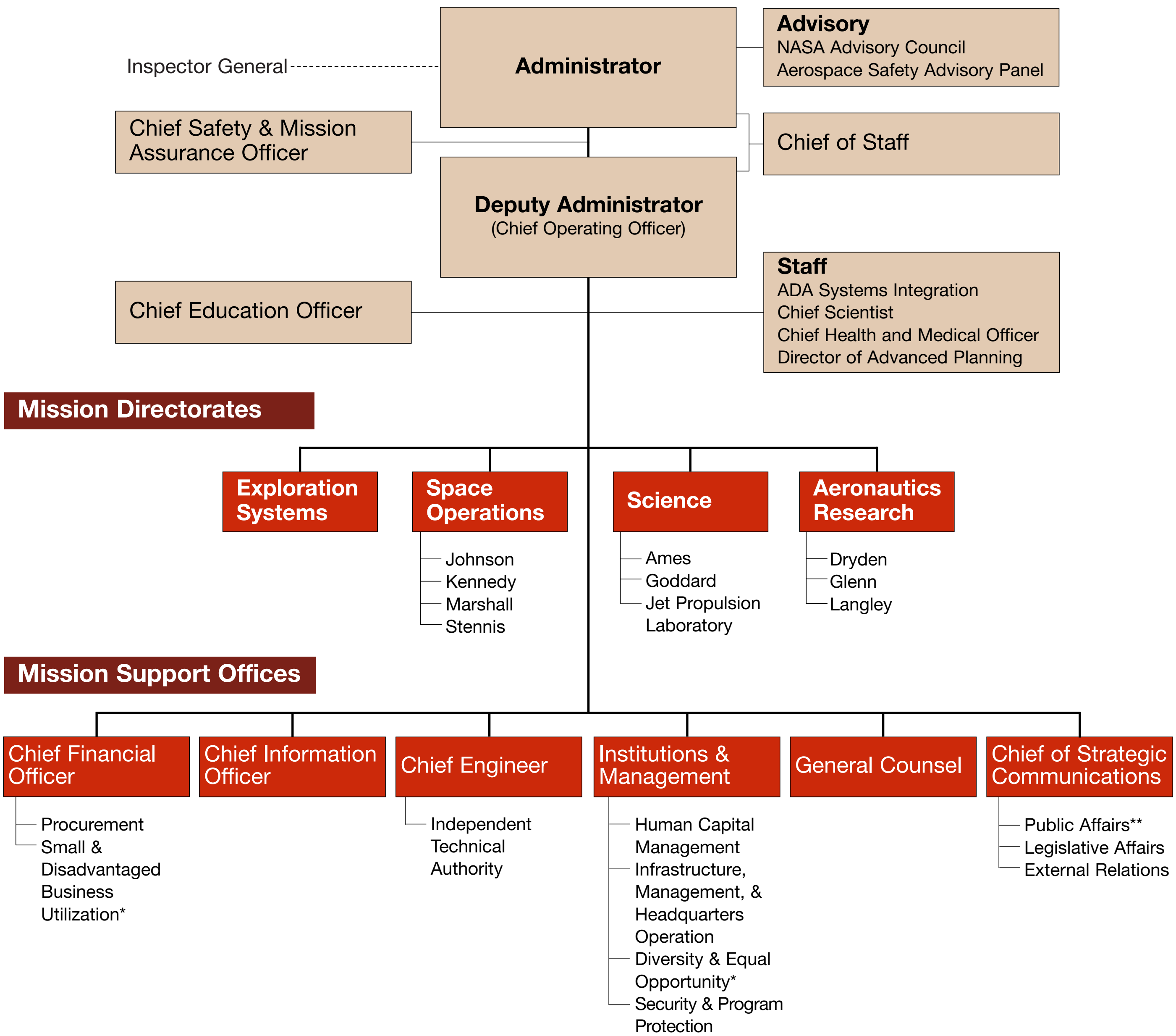
- Safety: NASA is committed, individually and as a team, to protecting the safety and health of the public, NASA's partners, NASA's people, and the assets that the public entrusts to the Agency. Safety is the cornerstone upon which NASA builds mission success.
- The NASA Family: NASA is a diverse team bound together in extraordinary endeavors. Every member of the NASA family respects, trusts, and supports one another. The NASA family mourns together, celebrates together, dreams together, and shares with one another the challenges facing the Agency.
- Excellence: NASA is committed to establishing and achieving the highest standards possible in engineering, science, management, and leadership as the Agency pioneers the future. NASA demonstrates and communicates an unquenchable spirit of ingenuity and innovation, thrives on new ideas and experiences, and continuously learns.
- Integrity: NASA embraces truthfulness and trust. Every member of the NASA family is open, honest, ethical, responsible, and accountable. The Agency enthusiastically and energetically accepts the important work of bettering the world for future generations.

We are working to insure that every member of NASA's organizational community understands NASA's Vision, Mission, and Values and seeks to demonstrate them in every aspect of the Agency's work. The Agency's Strategic Plan, both long-term goals and near-term outcomes and objectives, is derived from this Vision and Mission. And, together, the Vision, Mission, and Values are the underpinnings of NASA's spirit and resolve.

Transforming NASA: The Organizational Evolution

NASA's organization is comprised of NASA Headquarters in Washington, D.C., nine field Centers Nation-wide, 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 functions through 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 a large, "extended NASA family" of civil servants and allied partners and stakeholders. Together, this skilled, diverse, extended group of scientists, engineers, managers, and support personnel share the Vision, Mission, and Values that are NASA.

Figure 9: NASA's new organization (Administrator through Mission Support Offices).



* In accordance with law, the Offices of Diversity and Equal Opportunity and Small and Disadvantaged Business Utilization maintain reporting relationships to the Deputy and the Administrator.

** Including a new emphasis on internal communications.

The NASA organization chart is available at: http://www.nasa.gov/pdf/61295main_org_chart_20040804.pdf

The new NASA Headquarters organization eliminates the Enterprise "stove-pipes," promotes synergy across the Agency, and supports the long-term Vision for Space Exploration. NASA Headquarters now consists of the Administrator, the Deputy Administrator/Chief Operating Officer, four Mission Directorates (each headed by an Associate Administrator), and eight Mission Support Offices, including the Office of Safety and Mission Assurance and the Office of the Chief Education Officer.

The new Mission Directorates are:

- Aeronautics Research to research and develop aeronautical technologies for safe, reliable, and efficient aviation systems;
- Science to carry out the scientific exploration of the Earth, Moon, Mars, and beyond, to chart the best route of discovery, and to reap the benefits of Earth and space exploration for society;
- Exploration Systems to develop capabilities and supporting research and technology that enables 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
- Space Operations to direct space flight operations, space launches, and space communications, as well as the operation of integrated systems in low Earth orbit and beyond.

The Mission Support Offices include the Office of the Chief Financial Officer, the Office of the Chief Information Officer, the Office of the Chief Engineer, the Office of Institutions and Management, the Office of the General Counsel, the Office of Strategic Communications, the Office of the Chief Education Officer, and the Office of Safety and Mission Assurance. NASA also created four new entities to improve the internal decision-making process: the Strategic Planning Council, the positions of Director of Advanced Planning and Associate Deputy Administrator for Systems Integration, and the Operations Council. The NASA Chief Scientist and the NASA Chief Medical Officer also continue to be important members of the Agency's senior leadership team.

NASA currently is redefining the relationship of Headquarters and the Centers, as well as examining organizational structure options for the Centers themselves. Thus far, NASA's leadership has decided to assign a specific Mission Directorate Associate Administrator to each Center as a Headquarters Center Executive to oversee the Center's performance in implementing Agency policies and programs. NASA will announce other changes as the transformation evolves and "One NASA" is achieved.

NASA's Integrated Budget and Performance Planning Process

NASA's strategy for establishing, measuring, and achieving performance goals is simple: an integrated planning process that links budget and performance planning, tracking, and reporting. As previously noted, NASA was the first agency in the Federal government to receive a "green" rating in the PMA area of Budget and Performance Integration. The Agency achieved this rating by fully integrating its strategic, budget, and performance planning processes and documents.

PLANNING AND MEASURING PERFORMANCE

The current NASA Strategic Plan was updated in 2003. It is now being re-written for publication in 2005. The new Strategic Plan will reflect NASA's transformation and restructuring. However, the Agency expects that the practice of developing and integrating multi-level plans in support of the Agency Strategic Plan will continue.

The NASA Strategic Plan, combined with the Enterprise/Mission Directorate strategies and the Center implementation plans, forms the basis of NASA's integrated planning process. These plans enable the Agency to measure performance on a continual basis and make necessary adjustments to ensure that performance goals are achieved.

To ensure NASA's continual awareness of planned versus actual performance, in FY 2004, NASA implemented the Erasmus system, a management information system that provides access to information on budget and performance to enhance informed decision-making. NASA program and project managers submit budget and performance data to Erasmus on a regular basis. NASA leaders then get monthly reports from Erasmus giving them a clear picture of planned versus actual performance as well as performance trends and anomalies that have, or might, impact Agency performance. The Agency hopes that by the end of FY 2005, Erasmus will provide a complete picture of NASA's budget and performance achievements.

PERFORMANCE ASSESSMENT RATING TOOL

The Performance Assessment Rating Tool (PART) is an evaluation tool developed by the White House Office of Management and Budget to assess the effectiveness of Federal programs. NASA submits one-third of its program portfolios (known as Themes) to the Office of Management and Budget each year, resulting in a complete assessment every three years. In 2003, the Office of Management and Budget reviewed seven of NASA's Themes for performance effectiveness using the PART. These results were published with the President's Budget in February 2004. During

2004, the Office of Management and Budget reviewed six new Themes and re-assessed the International Space Station Theme. These results will be published with the President's Budget in February 2005.

NASA and the Office of Management and Budget are working together to ensure that performance measures reflected in the PART are consistent with the performance measures included in the Agency's annual performance plan and annual performance and accountability report.

PERFORMANCE MEASUREMENT CHALLENGES

NASA faces a number of unique challenges in measuring performance annually:

- 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 and technology that has not yet been developed.
- Many of NASA's programs and projects involve complex, high-risk research and development work.
- The Agency tracks and reports performance trends over four-year periods by tracking the Annual Performance Goal (APG) color ratings:
  - Blue: Significantly exceeded APG
  - Green: Achieved APG
  - Yellow: Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
  - Red: Failed to achieve APG, do not anticipate completion within the next fiscal year.
  - White: APG was postponed or cancelled by management directive.

While this method of tracking seems straightforward, applying it to NASA's performance measures is difficult for several reasons.

- The APG numbering scheme changes from one year to the next, and APGs often are added, deleted, or modified.
- Where APGs have been stable, color trends can show useful information. In other cases, as when the color rating of an APG shifts from "green" to "yellow" or from "blue" to "green," the trend or change might be the result of a number of factors other than deteriorating performance (e.g., resource re-allocations or shifts in priorities).
- Where APGs have not been consistent from year to year (e.g., the content or numbering scheme has changed), there may be little value in suggesting a trend.

In FY 2004, NASA added Performance Outcomes to the performance measurement system to help address the problem of tracking multi-year trends and making annual reports more valid. The Agency also is considering additional ways to improve the validity and reliability of trend tracking, including tracking by Performance Objective or Strategic Goal. The Outcome color ratings are:

- Blue: Significantly exceeded all APGs. On track to exceed this Outcome as stated.
- Green: Achieved most APGs. On track to fully achieve this Outcome as stated.
- Yellow: Progress toward this Outcome was significant. However, this Outcome may not be achieved as stated.
- Red: Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
- White: This Outcome as stated was postponed or cancelled by management directive or the Outcome is no longer applicable as stated based on management changes to the APGs.

FY 2004 Performance Achievement Highlights

In FY 2004, NASA achieved or exceeded 85 percent of the Agency's 233 Annual Performance Goals (APGs—rated Green or Blue). NASA made significant progress in another six percent of the Agency's APGs (rated Yellow). The remaining nine percent either were not achieved (rated Red) or were not pursued due to management decisions (White). (See Figure 10 for the summary of NASA's APG ratings for FY 2004.) In addition, NASA is on track to achieve or exceed 93 percent of its 132 multi-year Outcome goals.

As discussed previously, NASA's principal strategy for achieving the Agency's performance goal is an integrated budget and performance process based on NASA's Strategic Plan and Integrated Budget and Performance Document. Therefore, the Performance Achievement Highlights reflected in the following pages are organized according to the components of NASA's Strategic Plan: the Agency's Mission and its ten Agency Strategic Goals. These highlights showcase many of NASA's most significant program areas and spotlight some of the tangible benefits that NASA provides to its stakeholders by pursuing and achieving its goals.

Over NASA's history, many of the technological advances achieved in pursuit of aeronautics research and space exploration have yielded unexpected commercial applications, or "spinoffs," that benefit the world's citizens. NASA is proud of this significant return on investment to the U.S. economy. To highlight some of these recent technology transfer successes, this report includes "Spinoff Spotlights" in the sidebars of this section.

This report does not include a report of budget allocations by strategic goal. NASA continues to work toward being able to allocate and report costs by strategic goal and objective. However, due to the continuing issues with financial data previously reported, the Agency cannot provide this information for FY 2004.

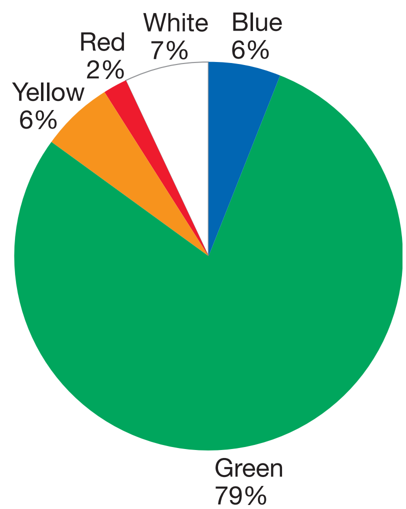


Figure 10: NASA achieved or exceeded 85 percent of the Agency's 233 Annual Performance Goals (APGs) in FY 2004.

APG Ratings

- Blue: Significantly exceeded APG
- Green: Achieved APG
- Yellow: Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
- Red: Failed to achieve APG, do not anticipate completion within the next fiscal year.
- White: APG was postponed or cancelled by management directive.

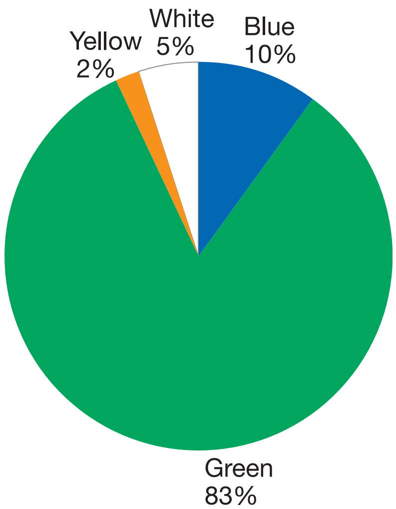


Figure 11: NASA is on track to achieve or exceed 93 percent of the Agency's 132 multi-year Outcome goals.

Outcome Color Ratings

- Blue: Significantly exceeded all APGs. On track to exceed this Outcome as stated.
- Green: Achieved most APGs. On track to fully achieve this Outcome as stated.
- Yellow: Progress toward this Outcome was significant. However, this Outcome may not be achieved as stated.
- Red: Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
- White: This Outcome as stated was postponed or cancelled by management directive or the Outcome is no longer applicable as stated based on management changes to the APGs.

Part 2 of this report is organized by the Agency's Missions, Goals, and Objectives, and includes a summary and color rating for each Outcome in NASA's FY 2004 Performance Plan. Part 2 also includes detailed performance data supporting the Performance Achievement Highlights including color ratings for each APG and trend information, where applicable. 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 in FY 2004.

The performance information in this report reflects data available as of September 30, 2004, unless otherwise noted.

Mission: To Understand and Protect Our Home Planet

GOAL 1

Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.

GOAL 2

Enable a safer, more secure, efficient, and environmentally friendly air transportation system.

GOAL 3

Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.

UNDERSTANDING EARTH'S SYSTEM

This year, NASA gained new insights into the systems that keep Earth working. Whether researching Earth's atmosphere or tracking hurricanes, wildfires, and icebergs, NASA brings a global view of Earth's complex interconnected systems into focus to help protect lives by predicting the natural phenomena that threaten this fragile planet.

Getting a better portrait of Earth's system

How is Earth's climate changing? Is the ozone layer recovering? Is air quality getting worse? On July 11, 2004, NASA successfully launched Aura, which joined 18 existing next-generation Earth-observing satellites to answer these important questions and to supply the best information yet about the health of Earth's atmosphere, oceans, and land. From the troposphere (Earth's surface) to the stratosphere, where the ozone layer provides a thin protective shield against solar radiation, Aura will provide an unprecedented and complete picture of Earth's atmosphere.

Credit: Northrop Grumman

Figure 12: The Aura satellite in the clean room prior to launch.

The changes in the composition of the atmosphere and its ability to absorb, reflect, and retain energy from the Sun affect the weather and climate on Earth. Aura's instruments will track both human-made and natural agents in Earth's atmosphere and will help scientists understand how atmospheric composition affects and responds to Earth's changing climate. Aura also will reveal the processes that connect local and global air quality, and it will track the extent to which Earth's protective ozone layer is recovering.

Gaining a global view of Earth will reap new scientific discoveries that will serve as essential stepping-stones to further exploration of the Moon, Mars, and beyond, the basis of the Vision for Space Exploration.

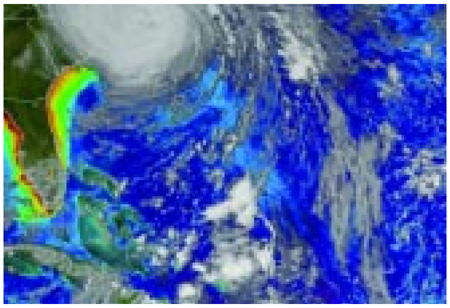
Aura's launch completed the first series of NASA's Earth Observing System satellites sent into orbit to study Earth's environment and climate change. The other satellites are Terra, which monitors land, and Aqua, which observes Earth's water cycle. In addition to tracking global climate change, Terra and Aqua perform many other tasks, including monitoring wildfires in the United States. Every day, the Moderate Resolution Imaging Spectroradiometers aboard the Terra and Aqua satellites provide images of fires across the country. NASA and the U.S. Forest Service developed a rapid response capability based on the direct broadcast of these images for wildfire management both during and after the event.

NASA Fact

Phytoplankton are tiny little plants that drift with the currents throughout the ocean. A teaspoon of sea water can contain as many as a million one-celled phytoplankton.

Hurricanes help plants "bloom" in ocean deserts.

NASA researchers recently proved that whenever a hurricane races across the Atlantic Ocean, microscopic plants called phytoplankton bloom behind it. Researchers tracked and analyzed levels of chlorophyll, the green pigment in plants, by monitoring ocean color data from the Sea-viewing Wide Field-of-view Sensor (SeaWiFs) instrument on the SeaStar satellite. An increased amount of phytoplankton has more chlorophyll, which satellite sensors can see.



Credit: NASA/Scientific Visualization Studio

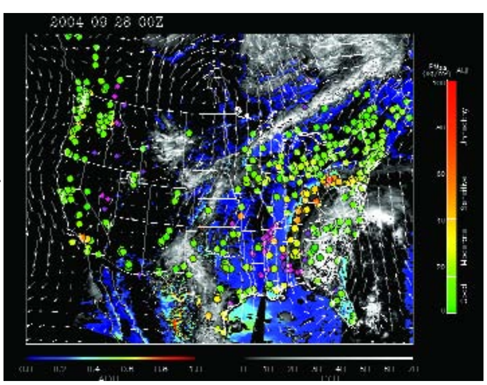
Figure 13: This SeaWiFS image of Hurricane Isabel on September 18, 2003, shows that as the hurricane passes, it leaves behind a trail of plankton blooms. The lighter blue areas represent higher amounts of chlorophyll and phytoplankton growth stimulated by the additional nutrients brought up to the surface following almost every storm.

Some parts of the ocean are like deserts because there is not enough food for many plants to grow. A hurricane's high winds stir up the ocean waters and bring nutrients and phytoplankton to the surface where they get more sunlight and bloom better.

This is the first experiment to track the effects of hurricanes in ocean deserts. Researchers found that the physical make-up of a storm, including its size, strength, and forward speed, is directly related to the amount of phytoplankton that blooms. Bigger storms appear to cause larger phytoplankton blooms. Since phytoplankton is at the base of the ocean food chain, their health and abundance directly affect all of the higher life forms (e.g., fish, penguins) that rely on them for food. The increased blooms also may affect the Earth's climate and carbon cycle because as phytoplankton grow, they absorb atmospheric carbon dioxide, a heat-trapping greenhouse gas.

NASA'S SCIENCE AND TECHNOLOGY IMPROVES THE QUALITY OF LIFE ON EARTH

NASA and its partner agencies utilize NASA's satellite data to predict food and fiber production and air quality advisories. NASA and Environmental Protection Agency studies are comparing NASA satellite measurements of aerosols with Environmental Protection Agency ground measurements to support air quality forcasters who develop and issue air quality advisories to the general public. The Environmental Protection Agency recently used a NASA "prototype" near-real-time data-fusion product, including Environmental Protection Agency measurements of particulate matter to assess and demonstrate transport of aerosols into their region and to develop the air quality advisories. The successful demonstration of this prototype is leading to improved operational advisory forecasts.



Credit: NASA/C. Raxworthy

Figure 14: A composite of NASA aerosol and cloud data, in-situ EPA data, and NOAA wind and fire data, taken on September 30, 2004, used to make air quality predictions that are issued to the public.

NASA's Earth satellite observing systems also are used by U.S. Department of Agriculture Foreign Agricultural Service to improve the accuracy and timeliness of information they provide about worldwide

SPINOFF SPOTLIGHT

Forecasting weather with a wave of the hand

NASA is always looking for new educational tools to capture children's attention without restricting a teacher's presentation. A company that created gesture-recognition software that observes and interprets human hand motions and gestures for controlling devices, had a solution.

The company integrated the gesture recognition software into NASA's Virtual Astronaut software (a computer-based program that teaches students health, biology, and other sciences by allowing them to become "virtual" astronauts in space) to create a gesture-controlled kiosk for the Bioastronautics Exhibit at Johnson Space Center. Through simple gestures, visitors to the Exhibit could explore the International Space Station without leaving Earth.

Building on the success of their collaboration with NASA, the software company recently introduced a weather map management system that uses both body tracking and gesture recognition technology for televised weather reports. This software allows meteorologists to control their computerized weather maps with simple hand gestures and body movements, freeing them from scripts and reducing the preparation time for broadcasts. The software also gives forecasters the edge as they track late-breaking storms, shaving critical minutes from the time required to broadcast severe weather warnings.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

Credit: Cybernet Systems Corp.

Figure 15: New software enables a meteorologist to interact with weather maps through simple gestures and body movements.

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GOAL 3
Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.

crop conditions. The Foreign Agricultural Service information is used in decisions affecting U.S. agriculture, trade policy, and food aid. Observations and data products from instruments on NASA's Aqua and Terra satellites, combined with data from the TOPEX/Poseidon, Jason, and Tropical Rainfall Measuring Mission satellites are used to assess global agricultural conditions.

The Foreign Agricultural Service uses this data to measure lake and reservoir water levels in an operational manner and to monitor the duration of droughts, assess how much water is available for irrigated farmland in arid regions, and determine how much crop the region is able to produce.

ARCTIC WARMING AFFECTS WORLDWIDE CLIMATE

Recently observed changes in Arctic temperature and sea ice cover might be a harbinger of global climate changes to come, according to a NASA study titled "Recent Warming of Arctic May Affect Worldwide Climate," published in the November 1, 2003, issue of the American Meteorological Society's Journal of Climate. Researchers used NASA satellite sensors to monitor the annual Arctic ice cover and found that, compared to the 1980s, most of the Arctic warmed significantly over the last decade, with the largest temperature increases occurring over North America. The result has direct connections to NASA-funded studies conducted last year that found perennial, or year-round, sea ice in the Arctic is declining at a rate of nine percent per decade, and that in 2002, summer sea ice was at record low levels. Early results indicate this continued into 2003. Satellite data confirms that the ice is shrinking in extent and appears to be getting thinner. Researchers have long suspected that the loss of Arctic sea ice may be caused by changing atmospheric pressure patterns over the Arctic that move sea ice around and by warming Arctic

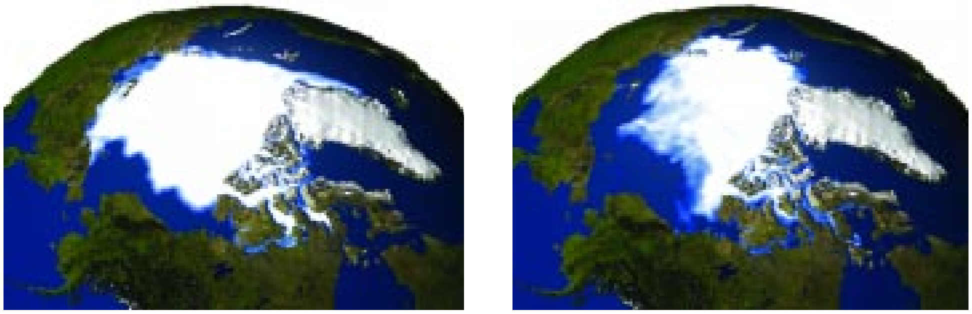


Figure 16: These images illustrate the magnitude of the difference in ice cover, which is about 1.6 million km^2, between 1980 and 2003. The comparisons show a dramatic decrease in the Arctic's ice cover.

temperatures that result from greenhouse gas build-up in the atmosphere. Warming trends in the Arctic waters affect ocean processes, ocean circulation, and the exchange of energy and water vapor between the ocean and atmosphere, which in turn impacts the Arctic and global climate.

NASA studies how these warming and melting trends affect the world. Satellite data allows researchers to see Arctic changes and helps them develop an improved understanding of the possible effect of the changes on worldwide climate. Arctic warming leading to reduced ice cover can cause a variety of atmospheric and oceanic anomalies affecting ocean circulation. This includes the possible redirecting of the Gulf Stream and other major currents. These anomalies can have notable effects on climate and agriculture worldwide. Better prediction enables better preparation for such changes.

UNDERSTANDING EARTH'S NEIGHBORHOOD

NASA gets a closer look at a comet

On January 2, 2004, NASA and the world got an unprecedented look at a comet when NASA's Stardust spacecraft successfully flew close to the nucleus of comet Wild-2. While near Wild-2's nucleus, Stardust collected thousands of dust particles from the comet which it will return to Earth for intensive chemical and physical tests in 2006.

Comets were formed about the same time as the planets, and scientists expect the samples from Wild-2 to provide important chemical clues about how the solar system was formed. Stardust's navigation camera also captured detailed pictures of Wild-2's pock-marked surface revealing sharply defined craters indicating that the material of the nucleus has internal strength—an unexpected result that contradicts the previously held theory that comet nuclei are aggregations of snow and dust held together loosely by gravity.

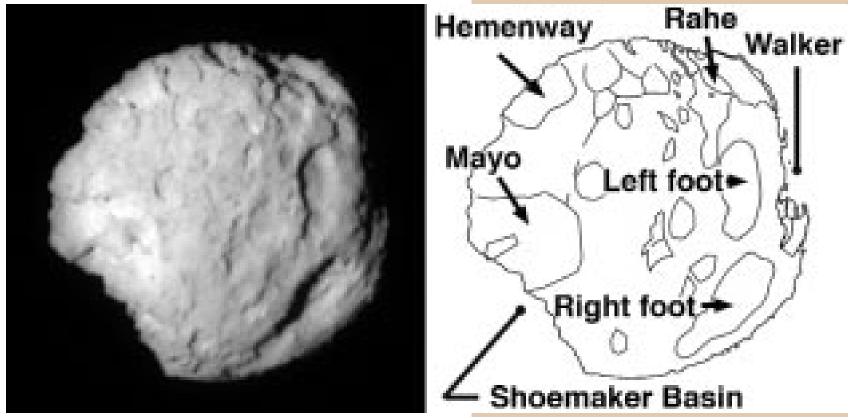
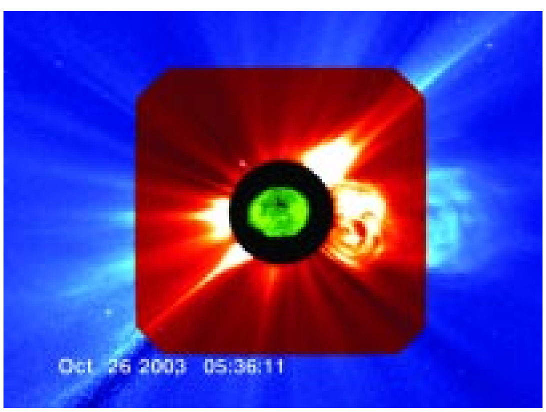


Figure 17: These images illustrate the magnitude of the difference in ice cover, which is about 1.6 million km², between 1980 and 2003. The comparisons show a dramatic decrease in the Arctic's ice cover.

Stardust is the first U.S. space mission dedicated solely to the exploration of a comet and the first robotic mission designed to return extraterrestrial material from outside the orbit of the Moon. The comet's samples, stored in Stardust's return capsule, are due to land in Utah on January 15, 2006.

NASA's spacecraft fleet tracks a blast wave through the solar system

This year, NASA's fleet of spacecraft throughout the solar system gave the best picture to date of the effects of blast waves from solar storms as they propagate through the solar system. The "Halloween" solar storms in October–November 2003 were the most powerful ever measured, producing spectacular effects throughout the solar system. The material hurled out by the huge solar storms raced past Earth at five million miles per hour. On Earth, the storms' effects caused a power failure in Malmoe, Sweden and disruptions in air travel, long-distance radio communications, and satellite operations. The storms also produced northern lights (aurora borealis) that were seen as far south as Florida. Within a few days, the storms produced half as much deadly particle radiation as the total emitted from the Sun in the previous ten years and created a new radiation belt around Earth that lasted for several weeks.



Credit: NASA/T. Bridgman and ESA

Figure 18: The Solar and Heliospheric Observatory spacecraft took this false color composite picture of the Sun during the Halloween 2003 solar storms. The sun is the center object in green. The area in red is a close-up view of the Sun's atmosphere (corona) where massive eruptions of electrified gas (plasma) called coronal mass ejections can be seen as white areas moving rapidly away from the Sun. The blue area is a wide-angle view of the corona.

NASA Highlight:
Tracking Hurricanes

NASA and NOAA use remote sensing observations to enhance hurricane track, landfall, and intensity forecasts. Measurements from NASA's Tropical Rainfall Measuring Mission and QuikScat Earth-observing satellites help improve predictions of hurricanes and other tropical systems as they move from the open ocean to coastal regions. Reducing hurricane track error means pinpointing precise regions for evacuation in advance of a predicted landfall. Better forecasts help save lives and property.

Figure 19: This image from the Moderate Resolution Imaging Spectroradiometer instrument on board NASA's Terra satellite shows Hurricane Frances off the coast of Puerto Rico on August 31, 2004.

Mission: To Understand and Protect Our Home Planet

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Only recently have enough spacecraft been in place to observe such blast waves as they zipped by Earth within a day and past Mars a few hours later. The Ulysses spacecraft near Jupiter and the Cassini spacecraft near Saturn both detected radio waves from magnetic storms generated as the blast wave slammed into the vast magnetic fields around those giant planets. NASA's twin Voyager spacecraft, located at the edge of the solar system, made the most distant observations.

This kind of event, and the ability to track it, has significant implications for radiation protection requirements for explorers who venture outside Earth's protective magnetosphere (magnetic field). Scientists have been working for years to develop the capability to predict when these massive storms will erupt. With the data collected from NASA's fleet of observers, scientists are getting closer to understanding how solar storms work and how to protect Earth and its explorers from their effects.

WORKING TOWARD SAFER, MORE EFFICIENT FLIGHT

Since its creation, NASA has worked on developing technologies and systems to make air travel safer and more efficient. This year, NASA continued these efforts both on the ground and in the air with Agency partners from the Federal Aviation Administration and industry. The result? A future with reduced flight delays and trip times and more time at the traveler's destination.

Creating safer skies, from the ground up: Advances in air traffic management

From increasing information sharing between pilots and air traffic controllers to detecting aircraft that have gone off-course and helping pilots "see" through the fog, NASA made great strides this year to improve and modernize the national airspace and air transportation systems.

Seeing through the fog

"What I really need is a pair of spectacles to see through the fog," declared Charles A. Lindbergh during his historic solo flight across the Atlantic in 1927. Almost eight decades and a host of technological advances later, NASA's Langley Research Center and its government, industry, and university partners are working on the equivalent of Lindbergh's fog-penetrating spectacles.

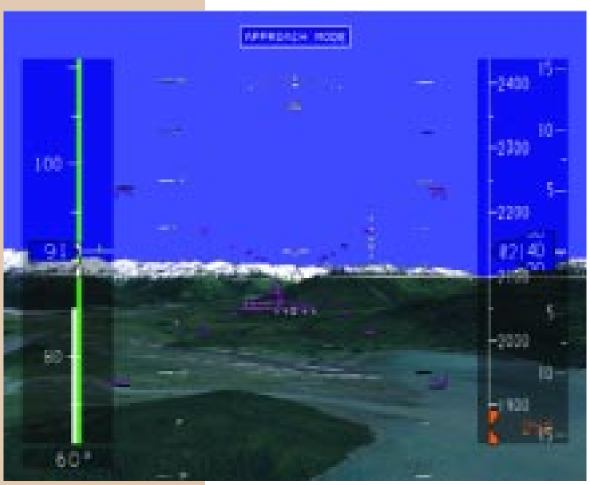

Figure 20: Simulations and flight studies show that the Synthetic Vision System increases pilot situational awareness and reduces errors and workload.

Test flights on a Gulfstream V, a small private aircraft, demonstrated that NASA's consortium of researchers has brought "tunnel-in-the-sky" Synthetic Vision Systems to an impressive level of functionality. The pursuit of this system is part of NASA's Aviation Safety and Security Program to cut fatal accident rates by 80 percent over 10 years.

Eliminating low-visibility-induced accidents—such as miscalculating altitude relative to the elevation of terrain and flying into it during poor weather and/or at night—is one way to cut accident rates. The new system will improve situational awareness by giving pilots "enhanced vision," sensor-based information about terrain and man-made features when visibility is obscured. The Synthetic Vision Systems create an artificial, computer-generated view based on a detailed terrain database.

Although the pilot may not be able to see the ground through the fog, a computer screen presents the landing site accurately based on map and terrain information.

Better flight from the ground up

Sooner or later, every frequent traveler will experience it—sitting on a jet as it waits in line to take off or as it circles an airport waiting for permission from the tower to land. It is the inevitable result of too many jets vying for too little runway space. But, help is on the way. NASA, in collaboration with the Federal Aviation Administration, completed operational tests and a cost-benefit assessment for a Surface Management System computer program that will assist air traffic controllers and air carriers in managing the movement of aircraft on the airport runway, thereby improving runway capacity, efficiency, and flexibility. This program provides near-term predictions of runway delays and forecasts of total daily demand for a runway to support strategic surface planning. This capability also allows air traffic controllers, pilots, and airline officials to collaborate, plan, and make decisions based on shared information. Once in use at airports, this system will help air traffic controllers and air carriers move flights easily and safely from heavily used runways to runways that are away from congestion, preventing back ups on the ground and in the air and speeding passengers to their destinations.

Staying the course—detecting off-course planes

Restricted airspace, areas where aircraft are not allowed to fly without permission, exists throughout the U.S. These areas protect top-secret military sites and places of special value, such as the White House in Washington, D.C. Occasionally, civilian aircraft accidentally fly into restricted airspace. More rarely, aircraft deliberately breach these protected areas, so the Federal Aviation Administration must closely monitor all flights—and NASA is helping. NASA demonstrated the prototype of a computer program designed to detect aircraft that deviate from their flight plans. The Fort Worth, Texas, and Washington, D.C., air traffic control centers evaluated the Rogue Evaluation And Coordination Tool using a live traffic feed over eight hours. During the evaluation, the program demonstrated the ability to detect aircraft that are deviating from their expected flight paths and predict entry into restricted airspace. Tools like this will enhance public safety by mitigating the potential for catastrophic harm that could result from a rogue aircraft.

Supersonic flight for everyone—another step closer

In support of NASA's goal of a safer and more efficient air transportation system, the Agency has developed and demonstrated technology that may one day enable unrestricted supersonic flight (faster than 750 miles per hour at sea level) over land and improve supersonic flight performance and safety.

Supersonic aircraft can fly faster than the speed of sound. When they surpass this invisible sound barrier, a shockwave is formed, and a loud sonic boom is heard on the ground. Although sonic booms last less than a second, they can be disruptive and annoying to people and animals and can even cause damage to buildings. As part of an effort to identify and mature technologies that could reduce sonic booms, a major hurdle to unrestricted supersonic flight, NASA and the Defense Advanced Research Projects Agency conducted the Shaped Sonic Boom Experiment to test the theory that by altering the contours of a supersonic aircraft, the shockwave and its accompanying sonic boom can be shaped, greatly reducing how loud the sonic boom sounds on the ground.

SPINOFF SPOTLIGHT

The perfect mate for safe fueling
Like a lifeline, an umbilical transports what a space vehicle needs to keep functioning—power, communications, instrument readings, and fluids like propellants, pressurization gases, and coolants.

Numerous launch vehicles, planetary systems, and rovers require umbilical "mating." With future space vehicles in mind, NASA designed a smart, automated method for quickly, safely, and reliably mating and demating electrical and fluid umbilical connectors.

A small company recently partnered with NASA under a Small Business Innovation Research contract to develop this umbilical system for commercial use. The system can be used safely to fuel commercial aircraft at airport terminals, trucks at truck stops, military vehicles in the field or at depots, and fleet automobiles at service stations and depots. NASA also is considering the umbilical system for methane-fueled Mars exploration rovers.

Figure 21: The umbilical system is one of the most advanced fueling systems currently available because it decreases the need for human intervention during potentially dangerous fueling operations.

With its ability to connect, disconnect, and reconnect during any point in the countdown process, the new umbilical system could lead to cheaper, safer, and more reliable launches for all future space vehicles.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

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NASA Fact

The first piece of the International Space Station to be placed into orbit was the Zarya control module. It was placed in orbit in November 1998 by a Russian Proton rocket.

Figure 22: Northrop-Grumman Corporation's modified U.S. Navy F-5E Shaped Sonic Boom Demonstration Aircraft.

The Shaped Sonic Boom Experiment included 21 supersonic flights on a modified F-5E aircraft at speeds in excess of 1,000 miles per hour at altitudes ranging from 32,000 to 34,000 feet. Flight test data gathered from supporting aircraft and ground sensors proved NASA's theory and paved the way toward improving and extending supersonic flight.

In a related study, NASA completed testing on a new type of inlet (a component that regulates airflow into aircraft engines for speed and lift capability) for supersonic propulsion systems. The Supersonic Parametric Inlet tests helped refine the inlet's performance through adjustments to the inlet geometry. Unlike typical inlets for supersonic cruise that rely on a mix of external and internal air compression, this inlet accomplishes all of the supersonic compression outside the engine. The tests showed that the inlet's performance was comparable to typical inlets with the added benefit of lower weight and the elimination of "unstart." This condition occurs when supersonic shock waves enter a jet inlet and are expelled, drastically reducing the amount of air that can pass through the engine, causing a loss of thrust and a dramatic rise in drag. Unstart is a recurring safety problem in propulsion systems with mixed compression inlets.

COLLABORATING WITH OUR PARTNERS

Working on the final International Space Station configuration

Space agency leaders from the United States, Russia, Japan, Europe, and Canada met at the European Space Agency's Technical Centre in the Netherlands in July 2004 to discuss Station cooperative activities. At the meeting, the Station partnership unanimously endorsed a proposed technical configuration and reviewed the status of on-orbit operations and plans. When the International Space Station is completed by the end of the decade it will accommodate on-orbit

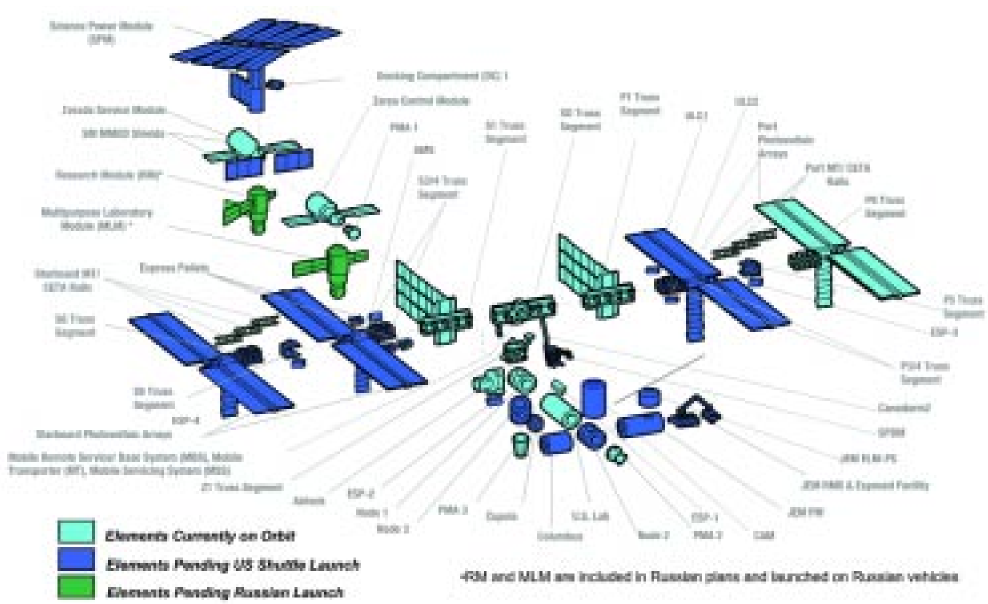

Figure 23: The ISS technical station configuration endorsed at the July 2004 meeting.

elements from each of the partners, enable increased Station utilization, and will provide opportunities for a crew of greater than three people.

The International Space Station will be supported by a number of spacecraft including Russian Soyuz vehicles, the U.S. Space Shuttle, Russian Progress vehicles (for re-supply and re-boost), the Automated Transfer Vehicle being built for the European Space Agency, the Japanese H-II Transfer Vehicle, and potentially new commercial vehicles.

Research continues onboard the International Space Station

While international space leaders cooperated on the ground, astronauts continued their international cooperation onboard the International Space Station through several joint research activities, including the completion of a record-breaking 31-day experiment called PromISS-3. PromISS-3 utilized the Microgravity Sciences Glovebox, a sealed laboratory with built-in gloves for conducting experiments in space. The European Space Agency, in collaboration with NASA, developed the Glovebox to contain space-based experiments safely. Since the Glovebox can be sealed, astronauts are able to work with potentially hazardous experiments without small hardware parts, particles, fluids, and gases escaping into the open laboratory module and jeopardizing both the crew and the Station.

Figure 24: European Space Agency astronaut Pedro Duque of Spain is working on the Protein Crystal Growth Monitoring by Digital Holographic Microscope (PromISS) experiment, investigating the growth processes of proteins in weightless conditions.

Sponsored by the European Space Agency, PromISS-3 was an experiment to study the growth of protein crystals. Among the proteins grown were iron storage proteins found in all living things, proteins that help protect humans from bacterial infection, and proteins related to anemia and neuromuscular disease in humans. The experiment involved a holographic microscope that sent images of the growing crystals to researchers on Earth. The holographic microscope allowed scientists to study the physics involved in the growth of these types of crystals, helping them understand why some crystals grow better in space than others.

Predicting the risk of fire on space vehicles

NASA-sponsored research at the National Institute of Standards and Technology this year helped scientists make significant advances in understanding the role of carbon dioxide in the spread and extinguishing of fires in space environments. Researchers found that carbon dioxide can either raise or lower the flammability of certain fuels depending on the level of gravity. This has major consequences both for predicting the risk of fire on space vehicles and for comparing approaches to extinguishing fires.

The more scientists understand about how fires begin and spread, the better they will be able to avoid the risk that fires pose to crews and vehicles. Some of the mechanisms that cause fire to ignite and spread are the same in space and on Earth. A better understanding of the fundamental

SPINOFF SPOTLIGHT

Approaching suspicious substances safely

A mineral identification tool developed for NASA's Mars Rover Technology Development program is now serving as a powerful tool for U.S. law enforcement agencies and military personnel to identify suspicious liquid and solid substances.

The Raman spectrometer and fiber-optic probe for Mars exploration rovers use laser light reflected off of molecules in gases, liquids, and solids to identify a substance's makeup.

One of the major advantages of Raman spectroscopy over other analysis techniques is its ability to measure through clear and semi-clear containers.

The U.S. Army and the Federal Bureau of Investigation now use an improved version of the basic spectrometer for forensic and military applications. Thanks to NASA-sponsored research, the resulting tool, which fits into a portable kit, can measure unknown substances through glass and plastic packaging materials using a focused fiber-optic probe that can extend up to 650 feet. This allows users to analyze potentially dangerous substances from a safe distance.

NASA's partner company maintains a comprehensive database that contains hundreds of compounds of explosives, and they are expanding it to include pesticides and other toxic chemicals.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

Credit: EIC Laboratories, Inc.

Figure 25: Using a fiber-optic probe, the Raman spectrometer can analyze unknown substances through clear and semiclear glass and plastic packaging materials.

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NASA Fact

Around the world, the ozone layer averages about 3 millimeters (1/8 inch) thick, approximately the same as two pennies stacked one on top of the other.

mechanisms of fire ignition, transition from smoldering to flame, and fire spread on solid surfaces in space also will improve models of large-scale fire propagation on Earth and will represent a significant contribution to fire safety.

Innovative Partnership to Revolutionize Supercomputing

NASA is working with two major corporations, Silicon Graphics Incorporated and Intel, to increase the Agency's supercomputing capacity to meet critical national goals. The three organizations have formed an innovative partnership through Project *Columbia* to create the Space Exploration Simulator, one of the most powerful and sophisticated supercomputers to date. The new computer will be based at NASA's Ames Research Center in the heart of California's Silicon Valley. With over ten thousand processors, it will provide an estimated ten-fold increase in NASA's current supercomputing capacity, significantly increasing NASA's capabilities and fueling scientific breakthroughs in space exploration, global warming research, and aerospace engineering.

The limitations of NASA's current supercomputer became apparent during the *Columbia* accident investigation and Shuttle return to flight activities. The primary purpose of Project *Columbia* is to revitalize NASA's supercomputing capability through deployment of an integrated computing, visualization, and data storage environment tailored to NASA's needs.

"NASA is excited to be working with industry in an innovative way to allow the Agency to deploy a versatile capability in supercomputing," said NASA Administrator Sean O'Keefe. "This will enable NASA to meet its immediate mission-critical requirements for return to flight while building a strong foundation for our space exploration vision and future missions."

Federal Aviation Administration fuel-tank safety system tested with NASA's help

The Federal Aviation Administration and NASA have been working on technology to prevent fuel tank fires since July 1996, when TWA Flight 800, a Boeing 747-131, suffered a catastrophic fuel tank explosion. The jumbo jet crashed into the Atlantic Ocean near East Moriches, New York, killing all 230 people onboard. This year, an aircraft normally used to transport the Space Shuttle was pressed into service to test technology that will make airliners safer. NASA researchers arranged for a fuel inerting system to be installed aboard the NASA Boeing 747. The system is designed to reduce the chance of an explosion inside an airplane tank. As a plane uses fuel, excess air or oxygen remains in the tank and can accelerate fire. Fuel-tank inerting technology works by replacing excess oxygen in the fuel tank with nitrogen, which suppresses the fuel's flammability.

This year, the system made its first flight tests as part of ongoing research being conducted by Federal Aviation Administration and NASA. The Federal Aviation Administration had already tested the system using ground-based facilities. The next critical step in the technology development was to test the system aboard a large aircraft, such as NASA's 747.

NASA engineers also are studying next-generation advanced gas-separation technologies to produce affordable inert gas and fuels that are harder to ignite in the tank, reducing the number of fatal aircraft accidents.

Mission: To Explore the Universe and Search for Life

GOAL 4

Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.

Goal 5

Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

FROM RESEARCH TO REALITY

With a little help from our friends: Seeking input from the science community

NASA has been pursuing the difficult task of sending humans safely into space since its creation in 1958. The Agency is dedicated to returning a crew to the Moon and then extending human presence to Mars. To make this vision a reality, NASA scientists must understand how the human body functions in the space environment. For long duration flight, astronauts also must be able to grow food along the way. Toward this end, NASA solicits input and world-class, peer-reviewed research in the biological and physical sciences every year.

NASA sponsored a number of workshops this year organized around the challenges that living organisms experience in space and how space can help researchers understand living organisms better. The Agency also participated in workshops with outside groups like the Center for Advanced Studies in the Space Life Sciences, located at the Marine Biological Laboratory in Woods Hole, Massachusetts, which hosted "Animal Research in Support of Human Space Exploration" in April and "Science for Enabling Human Exploration" at the end of July.

Such workshops provide an excellent opportunity to communicate the results and benefits of space research to the public and to attract new researchers and students to the NASA family, ensuring that space research remains vital and on the cutting edge of science. The workshops also serve as the first step NASA takes before soliciting research proposals from the community because they offer a fertile environment for establishing research goals and roadmaps. Once these are established, NASA can release its solicitations: NASA Research Announcements. This year, NASA released six Research Announcements focused on biological physics, life sciences, and human health in space.

A new class of glass

Humans have been making glass for thousands of years, melting it, blowing it, and rolling it into beautiful, useful, and often fragile shapes. Thanks to NASA-sponsored research, a new type of metallic glass is doing something that glass has never done before—producing laser light for a variety of high-tech needs.

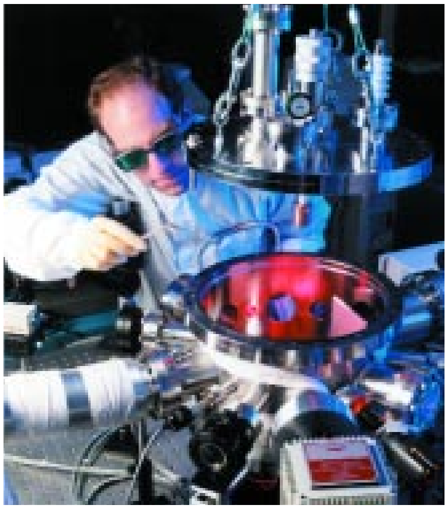


Figure 26: NASA's Electrostatic Levitator is a unique tool—one of only a few in the world—that allows researchers to study molten materials, such as metals, alloys, and metallic glass, in a containerless environment here on Earth. The levitator keeps the sample in a perfectly spherical shape, making it easier for researchers to understand the physical phenomena that are taking place within the sample.

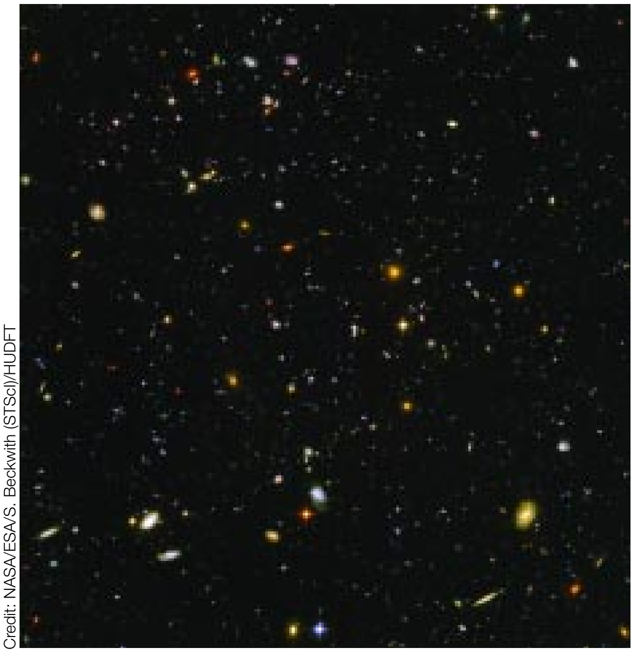
As part of a NASA research grant for a proposed International Space Station flight experiment, Dr. Richard Weber conducted ground-based research using NASA's Electrostatic Levitator. The levitator provides the perfect environment for investigating fragile liquids that are sensitive to temperature changes and have a viscosity (resistance to flow) that can change rapidly as the temperature drops. The levitator suspends the liquid in mid-air using static electricity while lasers heat the material until it is molten, allowing researchers to explore the properties of materials without interference from containers that can contaminate the sample.

Dr. Weber's research with the levitator led to a new glass made from rare Earth aluminum oxide. Called REAl Glass™, this metallic glass is very resilient and has optical qualities that make it ideal for use with lasers. Lasers normally use expensive crystals, like sapphires or rubies, as a lasing material to create a beam of laser light. The crystals' chemical and structural properties produce a specific operating wavelength, such as ultraviolet or green light, that limits how the laser can be used. REAl Glass, on the other hand, is less expensive to manufacture and can extend the range of wavelengths. This allows a surgeon, for example, to tailor the laser light to best suit the type of surgery. And, like other glass products, REAl Glass can be manipulated into a variety of shapes to fit a range of needs.

With the help of a Small Business Innovation Research award, Dr. Weber's company, Containerless Research, Inc., announced in October 2003 that they are marketing REAl Glass for commercial use in surgical and power lasers, optical communications devices, and sensors. Dr. Weber also is continuing his research with fragile liquid oxides hoping to discover more amazing materials.

EYES IN SPACE

NASA's telescopes are looking farther and farther into Earth's cosmic neighborhood, revealing a universe filled with drama and beauty. Each telescope is equipped with a set of instruments that allows it to use different wavelengths of light to obtain its own unique glimpse of the universe. Together, these telescopes form a portrait of the universe that no single telescope could achieve.



Credit: NASA/ESA/S. Beckwith (STScI)/HUDFT

Figure 27: The Hubble Ultra Deep Field shows 10,000 galaxies, all dating back to when the universe was still young. Although the image is studded with a variety of familiar spiral and elliptical galaxies, it also contains a number of oddly shaped galaxies that look like toothpicks or strings of pearls. These unusual shapes chronicle a time when the universe was more chaotic, before order and structure emerged.

Hubble Space Telescope

This year the Hubble Space Telescope, NASA's oldest space telescope, captured the deepest portrait of the visible universe ever achieved. The Hubble Ultra Deep Field is a portal in time, imaging the galaxies that formed shortly after the Big Bang, the cosmic event nearly 14 billion years ago that started forming and expanding our universe. The historic view is actually derived from two separate images taken over several months with the Hubble's Advanced Camera for Surveys and the Near-Infrared Camera and Multi-Object Spectrometer. Both cameras reveal galaxies that are far too faint to see through telescopes on Earth. The two cameras were designed to find galaxies that existed only 400 to 800 million years after the Big Bang (a short span of time by cosmic standards), during a time when galaxies were "quickly" evolving.

SPINOFF SPOTLIGHT

A bright idea for the eyes

The team that makes sure that NASA's space telescopes can peer into the vast distances of our universe also helped create a light bulb that eases eye strain.

Researchers from NASA's Space Optics Manufacturing Technology Center worked with commercial partners to develop a chrome-topped light bulb that directs 40 percent more surface illumination on work and reading surfaces than standard incandescent bulbs and lasts twice as long. The bulb's lightly frosted finish also reduces eyestrain by diminishing glare.

The Discovery Fund for Eye Research recognized the bulb as a useful light source for those who need enhanced lighting due to eye disease such as age-related macular degeneration, the number one cause of vision loss and legal blindness in Americans over sixty.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

Credit: Westinghouse

Figure 28: The light-enhancing bulb's chrome cap and body shape direct most of the light onto work surfaces. Standard light bulbs reflect the majority of the light off walls and ceilings.

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The Hubble Space Telescope also is helping researchers solve the mystery of dark energy, a form of energy that uniformly pervades the Universe and is currently causing the Universe to expand at an ever-accelerating rate. The mystery of dark energy may be the most important outstanding question in the physical sciences today. Its answers will determine whether the Universe ends in a "Big Crunch"—eventually collapsing on itself—or a "Big Rip" in which dark energy increases until galaxies, stars, planets, and even atoms are torn apart. The Hubble Space Telescope recently detected a half-dozen of the most distant supernovae ever observed. These were used to provide striking confirmation of the existence of dark energy. The Chandra X-Ray Observatory, by measuring the X-ray fluxes from clusters of galaxies, also provided confirmation of the existence of dark energy in a manner completely independent of that of the Hubble Space Telescope.

Spitzer Space Telescope

The Spitzer Space Telescope, NASA's newest space telescope, also has been focused on youth—in this case, young stars and planets. Equipped with infrared sensors that allow it to see objects hidden from optical observatories, Spitzer spent its first months of operation surveying planetary "construction zones," the dusty discs that circle young stars in the Taurus constellation. Some of the icy materials in the discs are coated with water, methanol, and carbon dioxide, similar to comets that may have endowed Earth with water and other life-enabling chemicals. Researchers previously found indirect evidence of these organic materials in space. This year, for the first time, researchers found definitive evidence of organic materials in the dusty, planet-forming discs.

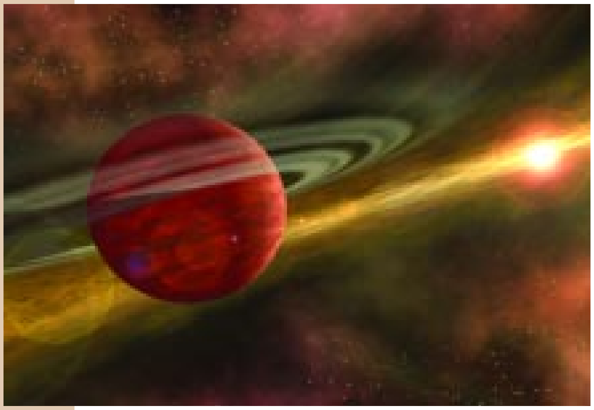


Figure 29: An artist's concept shows a newly formed planet clearing a path through the dusty disc encircling a young star.

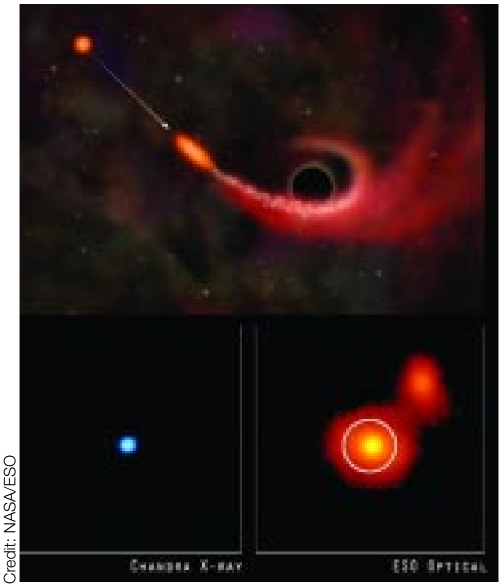
Credit: NASA/CalTech/E. Churchwell (Univ. Wisconsin)

Figure 30: Spitzer imaged the most prolific birthing ground in the Milky Way, a nebula called RCW 49. Because the multitude of stars are hidden behind clouds of dust, they cannot be seen at visible wavelengths. Spitzer's infrared array camera was able to see past the cloud to find older stars (blue), gas filaments (green), and dusty tendrils (pink), along with 300 never-before-seen newborn stars.

In another finding, Spitzer observed a clearing in the icy dust disc around the star CoKu Tau 4 indicating that it might be harboring a young planet. The star is only about one million years old; the hidden planet would be even younger. This may be the youngest planet ever detected, a mere newborn compared to Earth which is approximately four and a half billion years old. Spitzer also found two of the farthest and faintest planet-forming discs ever seen among a stellar nursery called RCW 49, within the Centaurus constellation. These findings suggest that planet formation is common and that Earth-like planets, which could support life, may not be unusual.

Chandra

While Spitzer was watching planets being born, two orbiting X-ray observatories, NASA's Chandra and the European Space Agency's XMM-Newton, were observing a far more destructive power at work. The observatories found the first strong evidence of a supermassive black hole ripping apart a star. Astronomers believe that the ill-fated star came too close to the giant black hole after being thrown off-course by a close encounter with another star. As the star was dragged in by the black hole's powerful gravitational pull, the star was stretched until torn apart. Chandra and XMM-Newton, along with earlier observations by the German Roentgen satellite, detected a powerful X-ray outburst from the center of galaxy RX J1242-11. The outburst, one of the most extreme ever detected in a galaxy, was caused by superheated gases emitted by the star as it was swallowed by the black hole. This discovery provides crucial information about how black holes grow and affect nearby stars. Researchers had some evidence that supermassive black holes exist in many galaxies, but looking for outbursts like this one represents a new way to search for black holes.



Credit: NASA/ESO

Figure 31: An artist's rendition shows a star being stretched as it is sucked in by a black hole. Because of the momentum and energy created by the process, only a small percent of the star's mass went into the black hole (indicated by the white stream). The rest was flung away into the surrounding galaxy. As the star was torn apart, it released a powerful X-ray burst. To a ground-based optical telescope, like the European Southern Observatory (ESO), the galaxy would look normal, as shown at lower right. To Chandra, however, the event appeared as the blue burst at lower left. The white circle at the center of the ESO image shows where Chandra spotted the X-ray burst.

Ground-based telescopes

As NASA's space observatories searched the deep, dark parts of the universe, astronomers on Earth demonstrated the continuing value of ground-based telescopes. NASA-funded researchers used the 48-inch Samuel Oschin Telescope at Palomar Observatory in California to find a small, planet-like body clinging to the fringes of the solar system. Called "Sedna" for the Inuit goddess of the ocean, the object is three times farther away from Earth than Pluto making it the most distant known planet-like body orbiting the Sun.

Figure 32: An artist's illustration of Sedna shows its extreme distance from the Sun, which appears as a bright star. Between Sedna and the Sun is a hypothetical small moon that scientists believe may be circling the distant planet-like body.

Sedna is likely the first object detected from the long-hypothesized "Oort cloud," a distant repository of small, icy bodies that supplies the comets that streak through this solar system. This tiny body lies in the coldest known region of the solar system where the temperature never rises above minus 400 degrees

SPINOFF SPOTLIGHT

A look from inside

The same technology that enhances Hubble Space Telescope images is now helping physicians perform micro-invasive arthroscopic surgery.

Over the last few years, a number of medical device engineering companies have partnered with NASA to bring micro-technology-based systems to the medical community faster and for less money than the companies could do on their own. One such company was developing a new micro-endoscope, a tool that allows surgeons to look inside the body using a tiny camera, eliminating the need for a more invasive diagnostic procedure.

The images from the micro-endoscope needed to be extremely clear—a challenge with the tool's small size. So, NASA supplied the expertise in image enhancement to the endoscope system to remove fiber patterns, lessen noise, sharpen the picture, and improve the color and illumination.

The real-time nature of the system allows physicians to make a diagnosis and immediately determine the next step in treatment.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

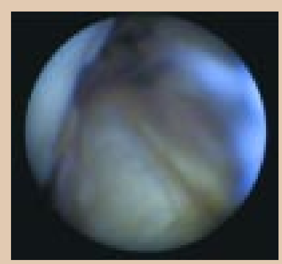


Figure 33: The system (below) provided this view of an Anterior Cruciate Ligament inside a knee.

Credit: Micro Medical Devices, Inc.

GOAL 4

Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.

Goal 5

Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

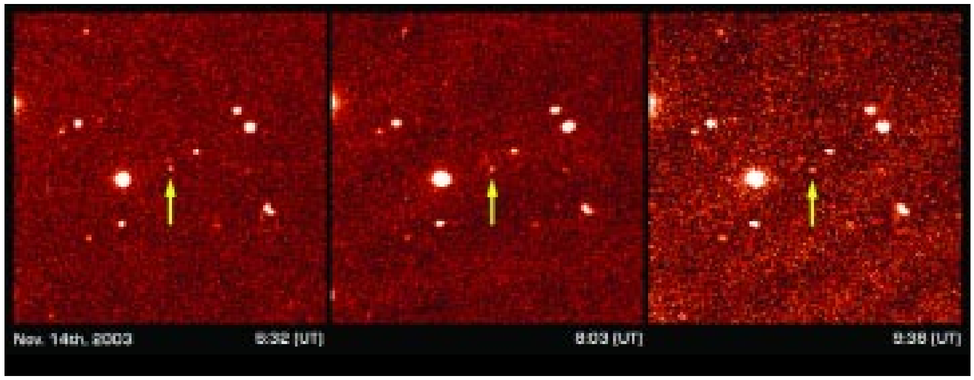
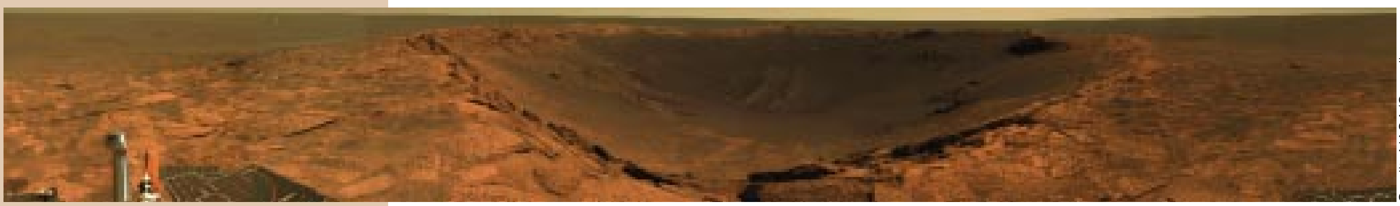


Figure 34: These three pictures show the first detection of Sedna. Imaged on November 14, 2003, from 6:32 to 9:38 Universal Time, Sedna (marked by the arrow) was identified by the slight shift in position over time.

Fahrenheit. Sedna is usually even colder because it approaches the Sun only briefly during its 10,500 year orbit. Scientists estimate that Sedna's size is about halfway between that of Pluto and Quaoar, the planetoid discovered by the same astronomers in 2002. Sedna is so cold and small that the Spitzer Space Telescope was unable to detect what little heat it emits.



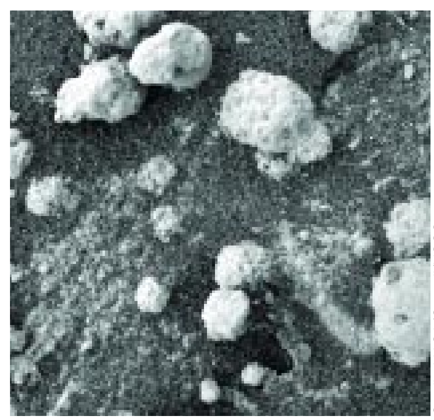
Credit: NASA/Cornell

Figure 35: The panoramic camera on NASA's Mars Exploration Rover *Opportunity* produced this approximate true color mosaic image from a position at the edge of "Endurance Crater."

VISITING CLOSE TO HOME

Spirit and *Opportunity* on Mars

While telescopes strained to see distant neighbors in the universe, other NASA missions visited Earth's planetary neighbors. The Mars Exploration Rover, *Spirit*, landed successfully in Mars' Gusev Crater on January 3, 2004, followed three weeks later by its twin, *Opportunity*, which landed on the other side of the planet in Meridiani Planum. *Opportunity* had the good luck to land in a small crater with an exposed outcrop of layered bedrock providing a bonanza of geological information.



Credit: NASA/Cornell/USGS

Figure 36: This view from the microscopic imager on NASA's Mars Exploration Rover *Opportunity* shows a type of light-colored, rough-textured spherules scientists are calling "popcorn" in contrast to the darker, smoother spherules called "blueberries."

Thanks to intense investigation by *Opportunity*, and even more intense scrutiny by researchers, NASA produced geochemical evidence that pools of liquid water once covered Meridiani Planum. The researchers also identified ripples created by currents and crystal molds in the sedimentary rocks, further supporting the conclusion that these rocks once sat in a shallow, salty body of water, perhaps at the edge of a shallow sea. Meanwhile, on the other side of the planet, *Spirit* was discovering evidence of ground water in Gusev Crater. *Spirit* found grey hematite, a mineral that forms when iron-oxide minerals react to water. Rust, a chemical twin of hematite with a different crystalline structure, is created in a similar manner. *Opportunity* also found hematite at the Meridiani site in the form of BB-sized spherical granules (nicknamed “blueberries” by the rover science team), which likely formed as liquid water soaked through the rocks. Buoyed by so much evidence of water, NASA is considering sending future sample return missions to these sites to look for evidence of life in Mars’ ancient past.

Flying rings around the Ringed Planet: Cassini and Saturn

Cassini, NASA’s flagship mission to the outer solar system, arrived at Saturn this summer opening a frozen time capsule to a bygone era. Data from Cassini’s June flyby of Saturn’s moon Phoebe showed that the tiny moon is a primordial mixture of ice, rock, and carbon compounds similar to those seen on Pluto or Neptune’s moon, Triton. Scientists believe that bodies like Phoebe were probably plentiful in the distant reaches of the solar system about four and half billion years ago. Many of these bodies were either swallowed up by the giant planets Jupiter, Saturn, Uranus, and Neptune or became moons of those planets. Others were ejected into distant orbits to help form the Kuiper Belt, a debris-field beyond Neptune filled with icy objects left over from the birth of this solar system.

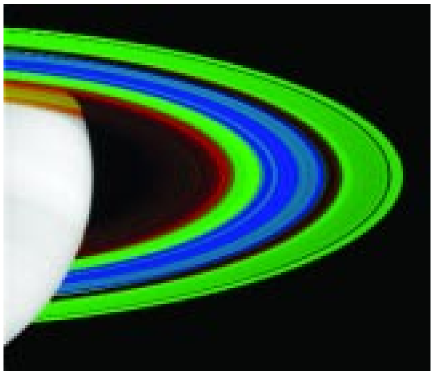


Figure 37: The varying temperatures of Saturn’s rings are depicted here in this false-color image from the Cassini spacecraft. The image was made from data taken by Cassini’s composite infrared spectrometer instrument. Red represents temperatures of about minus 261 degrees Fahrenheit, and blue minus 333 degrees Fahrenheit. Green is equivalent to minus 298 degrees Fahrenheit. Water freezes at 32 degrees Fahrenheit.

Cassini also imaged Saturn’s large moon, Titan, including its hazy atmosphere and exotic surface. Scientists theorize that the atmosphere of Titan may be similar to the ancient atmosphere that existed on Earth.

In December 2004, Cassini will release the European Space Agency’s Huygens probe. The probe will plunge through the atmosphere of Titan, gathering data as it descends by parachute to the surface. All eyes will be on Titan for clues to Earth’s distant past.

After entering orbit around Saturn in July, Cassini discovered two new moons, Mimas and Enceladus, hiding between Saturn’s moons. These moons, which may be the smallest bodies seen around Saturn, are each only about two and one half miles in diameter, or about the size of Boulder, Colorado.

Cassini’s orbit also is providing a closer view of Saturn’s most notable feature, its softly colored rings of ice and rocky debris.

The Cassini mission was launched in 1997, and its arrival at Saturn has proven well-worth the wait. It already has delivered a constant stream of information about Earth’s beautiful neighbor. By the end of the mission, scientists will have a much greater understanding of this vast, mysterious, and ancient portion of the solar system.

SPINOFF SPOTLIGHT

How sweet it is

A revolutionary, low-calorie sugar substitute began its unusual journey to the commercial market 30 years ago when a NASA-funded investigator created a life detection experiment to place aboard the Mars Viking 1 and Viking 2 landers.

Although the experiment did not provide generally accepted proof of life on Mars, the investigator’s research into different forms of sugars led to another discovery: the human stomach does not digest all forms of sugar. Some complex molecules exist in two forms. In sugars, these two forms are referred to as D and L, and humans only eat and metabolize the D form.

The researcher theorized that since the human stomach does not digest the L-glucose, it might serve as a low calorie sweetener. And, while L-glucose passed taste tests and was patented as a low-calorie sweetener, it could not be manufactured economically enough for commercial use.

The researcher then examined another substance called D-tagatose. This is similar enough to L-type sugars to cause the human stomach to digest only a small percentage of it, so it is low in calories. D-tagatose also can be produced inexpensively.

Tagatose is 92 percent as sweet as table sugar and can be used as a one-to-one sugar replacement. Tagatose browns like regular sugar during baking, does not have an aftertaste like some high-intensity sweeteners, is a safe sweetener for diabetics, and does not promote tooth decay.

Tagatose is now being used by a number of food product companies for low-calorie, low-carbohydrate products. In December 2003, a partner company began marketing Tagatose’s uses in non-food products like toothpastes, mouthwashes, and cosmetics.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

Mission: To Explore the Universe and Search for Life

GOAL 4
Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

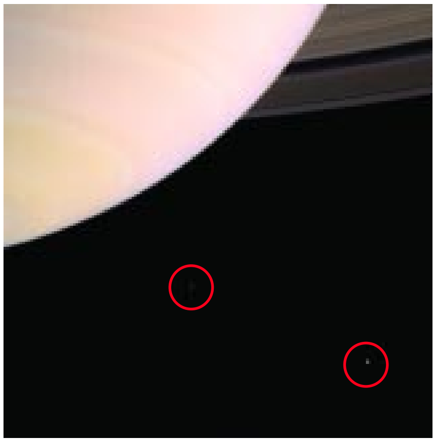


Figure 38: Saturn's atmosphere is prominently shown with the rings emerging from behind the planet at the upper right. The two moons near the bottom of the image are Mimas and Enceladus. This image was taken on August 8, 2004, with the Cassini spacecraft narrow angle camera in red, green, and blue filters. This image was taken 8.5 million kilometers (5.3 million miles) from Saturn. Contrast has been enhanced to aid visibility.

Sending a MESSENGER to Mercury

In August, a Delta II rocket carried the Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) spacecraft away from Earth toward the solar system's innermost planet. Like Earth, Mercury, Venus, and Mars are terrestrial, or rocky, planets. Of these, Mercury is the smallest and densest with the oldest surface. It is also the least explored of Earth's rocky neighbors. Mariner 10 sailed past Mercury three times in 1974 and 1975, but only gathered data on less than half of the planet's surface. Armed with seven scientific instruments and a durable composite frame

Credit: NASA/Space Science Institute

Figure 39: Nine days before it entered orbit, Cassini spacecraft captured this exquisite natural color view of Saturn's rings. The images that make up this composition were obtained from Cassini's vantage point beneath the ring plane with the narrow angle camera on June 21, 2004, at a distance of 6.4 million kilometers (4 million miles) from Saturn.

Figure 40: MESSENGER began its journey to Mercury before dawn on August 3, 2004. Along the way, the spacecraft will use Earth, Venus, and Mercury to adjust its speed and course before finally entering orbit around Mercury in March 2011.

to withstand being so close to the Sun, the solar-powered MESSENGER spacecraft will provide the first images of the entire planet. It will collect detailed information on the planet's crust and core, its geologic history, and its exotic, thin atmosphere and active magnetosphere. Researchers are hoping to answer several questions about this mysterious planet: Why is Mercury so dense? Why is Mercury the only terrestrial planet besides Earth to have a global magnetic field? How can the planet closest to the sun, with daytime temperatures near 840 degrees Fahrenheit, have what appears to be ice hiding in the permanently shaded polar craters as some Earth-based measurements suggest? More important, researchers are hoping to gain a better understanding of this solar system and how Earth and its terrestrial neighbors were formed.

NASA Fact

Four days after it was launched, the Deep Space 1 spacecraft was about 1,000,000 kilometers (about 600,000 miles) from Earth. To fly that far in a jet, you would have to fly for 6 weeks without stopping!

Mission: To Inspire the Next Generation of Explorers

Goal 6

Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics

Goal 7

Engage the public in shaping and sharing the experience of exploration and discovery.

REACHING OUT TO TOMORROW'S EXPLORERS

Educators "fly high" with the NASA Explorer Schools Program

In April, six educators from three NASA Explorer Schools took a giant leap closer to space when they flew aboard NASA's KC-135A aircraft. The KC-135A is a flying science laboratory that alternates steep climbs and dives to give riders the feeling of weightlessness without leaving Earth. While onboard the KC-135, teachers from Pender Public School in Pender, Nebraska, Crossroads Elementary School in Saint Paul, Minnesota, and Sioux Central Middle School in Sioux Rapids, Iowa, performed experiments planned by their students in the months leading up to the flight. Students and teachers from the participating schools worked with NASA scientists and NASA education specialists to develop experiments that could be tested in the near-weightless environment of the KC-135.

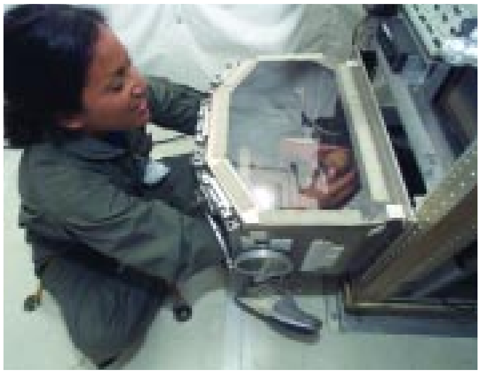


Figure 41: NASA Explorer School educator Alissa Kuseske uses a small glovebox to perform her students' spinning tops experiment onboard the KC-135. The glovebox kept the tops from floating around the cabin during the jet's roller coaster-like dives.

One of the educators, Alissa Kuseske, had this to say about her flight: "Astronaut Dan Barry gave me this advice before I flew on the KC-135. 'Remember to take the time to make the memory.' I took the time to look around the cabin when Flight Director John Yaniec yelled those three spectacular words, "Over the top!" I took the time to memorize the feeling of the body floating so I could bring the memory back to my students and family. It really was important to me to get it right; I didn't want to miss a second. This was my dream, and it could very well be a student's dream in my classroom or school. I wanted to make sure I made my time in the KC-135 count. I could not let my students down."

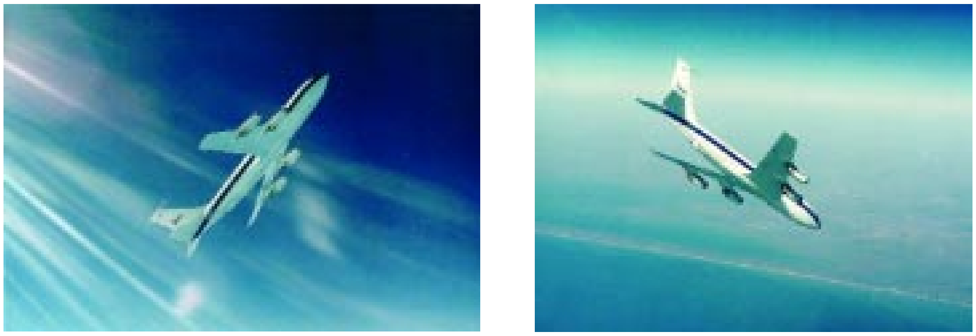


Figure 42: A typical flight mission on a KC-135 lasts about two to three hours. During each steep dive, the passengers experience 20 to 25 seconds of reduced gravity.

The NASA Explorer Schools Program, started in June 2003, establishes a three-year partnership between NASA and 50 new NASA Explorer School teams annually. The teams consist of teachers and education administrators from diverse communities across the country. During the commitment period, NASA invites teams to NASA Centers to spark innovative science and mathematics instruction directed specifically at students in grades four through nine. While partnered with NASA, Explorer School teams acquire and apply new teaching resources and technology tools using NASA's unique content, experts, and other resources. Schools in the program are eligible to receive funding (pending budget approval) over the three-year period to purchase technology tools that support science and mathematics instruction. This partnership provides a wonderful opportunity for students to participate in hands-on experiences with NASA science and technology, encouraging them to apply this knowledge to everyday issues and problems.

The NASA Explorer Schools model also is being shared with NASA's International Space Station partner countries. This fiscal year, the Dutch Ministry of Education began collaborating with NASA and the European Space Agency to establish a similar system of schools in the Netherlands modeled after the NASA Explorer Schools. Program managers from NASA and the European Space Agency are selecting components and best practices that have been successful in the Explorer Schools Program and incorporating them into a program that meets the needs of Dutch students and teachers.

NASA's Educator Astronaut Program: Teachers reaching for the stars to help students see learning in a whole new light

The Astronaut Candidate Class of 2004 has eleven new faces. Among them are three classroom teachers who are embarking on a bold, new adventure as part of NASA's Educator Astronaut Program. Mission-Specialist Educators Joe Acaba, Ricky Arnold, and Dottie Metcalf-Lindenburger received their blue flight suits on May 6, signifying that they are now full-fledged astronaut candidates. They will help lead NASA's development of new ways to connect space exploration with the classroom and inspire the next generation of explorers. The candidates reported to NASA's Johnson Space Center where they began intensive astronaut training, including land survival training, T-38 jet ground and flight training, Shuttle orbiter systems training, Space Station systems training, science and engineering briefings, and orientation tours at all NASA Centers.

Figure 43: From right, Richard R. (Ricky) Arnold II, Dorothy M. (Dottie) Metcalf-Lindenburger, and Joseph M. (Joe) Acaba, are mission specialist-educators in NASA's 2004 class of astronauts.

Recognizing that astronauts could not do their jobs without a crew here on Earth, NASA created a virtual team called Earth Crew to complement the Educator Astronaut Program. Each Earth Crew team is made up of students and one or more teachers or parents who use NASA's Edspace Web site (http://edspace.nasa.gov/) to plan and conduct exploration-related activities. Earth Crew team leaders receive E-mail updates and information about new Earth Crew projects, and team members provide suggestions to help plan new NASA education projects. As of October

Figure 44: Astronaut George Zamka works hand in hand with a student in building paper-based models as part of NASA's Educator Astronaut Program.

SPINOFF SPOTLIGHT

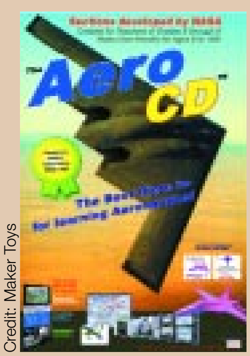
Students soaring high with software spinoff

An educational software product designed by the Educational Technology Team at NASA's Ames Research Center is bringing aeronautical work performed by NASA engineers to the public in an interactive format for the first time. The "Exploring Aeronautics" multimedia CD, created for use by teachers of students in grades 5 through 8, offers an introduction to aeronautics and covers the fundamentals of flight, including how airplanes take off, fly, and land. It contains a historical timeline and a glossary of aeronautical terms. The CD also examines different types of aircraft and familiarizes students with tools used by researchers to test aircraft designs.

A toy maker came to NASA looking for materials and images that he could use to create an educational CD "learning toy" for his company. "Exploring Aeronautics" was a perfect fit because it contains lively animation, movies, and tools to introduce students to NASA's scientific methods in the world of aeronautics.

This year, the company that licensed "Exploring Aeronautics" is working with science/education distributors, and mass-marketers to get "Exploring Aeronautics" to the target audience.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*



Credit: Maker Toys

Figure 45: The "Exploring Aeronautics" multimedia CD for students.

Mission: To Inspire the Next Generation of Explorers

Goal 6

Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics

Goal 7

Engage the public in shaping and sharing the experience of exploration and discovery.

2004, close to 123,000 people were registered as Earth Crew members. Approximately 87,000 of these are students, and 36,000 are adults.

The Educator Astronaut Program is targeted at grades five through eight to spark children's interest in science, mathematics, and engineering, ensuring that there will be a large pool of scientific and technical leaders in the future. All NASA education programs direct talented and diverse students into targeted opportunities and experiences that inspire them to choose NASA-related careers.

NASA brings space and science to blind students

The sky was no limit for a dozen blind high school students who had an opportunity to immerse themselves in real "rocket science" this August. NASA made its resources and facilities available as part of a program to provide the first-ever science camp for blind middle- and high-school students from across the United States. Over the course of five days, the students learned about the history of rocketry, basic rocket physics, and basic electronics, and they had the chance to build electronic sensor circuits for a rocket they helped launch from NASA's Wallops Flight Facility in Virginia. NASA and the students launched the 10.5 foot rocket during a three-hour available launch opportunity window.

Science camp counselors/instructors used a number of adaptive technologies, including software technology, developed at NASA's Johnson Space Center by the Learning Technologies Team. The tool—Math Description Engine—provided students with audible signals and sound descriptions of graphs generated by the rockets' data. Through these audible signals, the students were able to determine the readiness of their experiments and the rocket. The student-built electrical circuits allowed them to measure light, temperature, acceleration, and pressure during the rocket's flight, which reached an estimated altitude between 4,900 and 6,000 feet. After the flight, the students analyzed the data collected by the four sensors during the flight and presented their results to the NASA team.

The science camp program, called Rocket On, is free, made possible by funding and support from NASA, the National Federation for the Blind, the Lockheed Martin Foundation, the Maryland Space Grant Consortium, the Southeast Regional Clearinghouse, and the Maryland Science Center.

NASA currently is adapting other educational materials for blind students. One recent project, *Touch the Universe: A NASA Braille Book of Astronomy*, is a book featuring stunning imagery taken by NASA's Hubble Space Telescope. Through tactile illustrations of stars, planets, and other heavenly bodies, blind students can literally touch the universe and experience its beauty for the first time. NASA's Johnson Space Center in Houston also is working on computer software that will allow blind students to track the progress of rocket launches through sound.

NASA Fact

Because Saturn is tilted, when its rings are facing Earth edge-on they "disappear" from our view. We now know this happens every 14 years or so, but poor Galileo questioned his sanity when they "disappeared" and then "reappeared" a few years later.

CELEBRATING MILESTONES: CENTENNIAL OF FLIGHT AND APOLLO 11 35TH ANNIVERSARY

Nostalgia and anticipation follow Apollo 11 anniversary

In July, NASA commemorated the 35th anniversary of the landmark day in 1969 when humans first set foot on another celestial body. Along with nostalgia, the anniversary of the Apollo 11 Moon landing also evoked anticipation since NASA's new Vision for Space Exploration calls for NASA to return to the lunar surface and then venture to points beyond.

Around the country, members of the NASA family planned a variety of activities to remember the determination and ingenuity that put Neil Armstrong, Buzz Aldrin, and Michael Collins into the history books. At NASA Headquarters in Washington, DC, NASA Administrator Sean O'Keefe recognized the Agency's first generation of lunar astronauts and former CBS News anchor Walter Cronkite as "Ambassadors of Exploration." At NASA's Johnson Space Center, home to the Mission Control Center that planned and directed the Apollo 11 lunar landing, employees were taken back in time with a classic car parade and a local "oldies" radio station on site broadcasting songs from 1969. Employees also saw "moon rocks" and geological samples of the lunar surface and enjoyed Moon Pies and ice cream.

NASA employees were not the only ones participating in the celebrations. Visitors to the Stennis Space Center in Mississippi witnessed a "Moon Tree" planting in which a Sycamore seedling (descended from seeds that traveled to the Moon aboard Apollo 14 as part of astronaut Stuart Roosa's personal belongings) was planted. At the Goddard Space Flight Center in Greenbelt, Maryland, visitors watched historic footage from the Apollo 11 landing projected onto large screens and participated in a talk about the history and future of lunar exploration.

First Flight Celebration

On December 17, 2003, the world celebrated the 100th anniversary of the Wright Brothers' first flight with a fully controlled, powered aircraft. Their achievement marked a change in transportation, making it faster and easier to cross continents and oceans and bringing a large world closer together. Tens of thousands of daily flights at airports worldwide prove that the airplane has changed lives dramatically. And the Wright Brothers' achievement continues to inspire inventors young and old around the world. NASA, together with Federal, state, local, and industry partners, celebrated this historic event in Kitty Hawk, North Carolina, with a series of education and outreach events, including a teleconference with astronauts aboard the International Space Station and an attempt to re-create the Wright Brothers' historic flight.

Figure 46: Child flying the NASA Wright Flyer during last year's First Flight Celebration.

NEW DIRECTIONS: INTRODUCING AMERICA TO THE VISION FOR SPACE EXPLORATION

Following the introduction of NASA's Vision for Space Exploration in January 2004, NASA reached out to share the Vision with the public through a series of exhibits and programs.

Exhibits

In July, NASA unveiled a new three-dimensional mini-theater exhibit at one of the largest air shows in the world, the Farnborough International Air Show. The exhibit, housed in a sextagonal dome theater, presents a five-surround-screen and surround-sound system paired, for the first time in an exhibition, with interactive flooring. The virtual reality immersive environment allows the viewer to experience being on the Moon and Mars, extending an invitation to the public to join NASA in this cosmic vision quest. The exhibit is scheduled to visit 20 general public events by the end of fiscal year 2005.

SPINOFF SPOTLIGHT

Showing some muscle in the classroom

Researchers of all ages are getting the chance to experiment with "muscles" thanks to a NASA research partnership and its outreach efforts. Commonly referred to as "artificial muscles," electroactive polymer materials are lightweight strips of highly flexible plastic that use electricity to bend or stretch. Since the materials behave like biological muscles, they may one day be used to replace damaged muscles or to make robots that move like insects, animals, or humans.

NASA partnered with the private sector to develop a family of artificial muscle systems capable of robotic sensing and movement for use in space exploration.

NASA's industrial partner also worked on two educational outreach products revolving around the artificial muscles. The kits are suitable for high school and college students and professional scientists and engineers.

The first educational kit focuses on the bending and flexing type of muscles while the second kit explores the chemically or electrochemically activated type. Both kits provide the users with the basic materials and items needed to create artificial muscles safely and to test them for movement and sensing.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

Credit: Environmental Robots, Inc.

Figure 47: The two science kits contain the basic materials needed to safely create and test artificial muscles.

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Programs

NASA unveiled its new Centennial Challenges program, a novel program of competitions offering cash prizes for the development of new space-related breakthroughs. Centennial Challenges will help fulfill the Vision for Space Exploration by stimulating innovation in fundamental technologies, robotic capabilities, and low-cost space missions through prize purses for specific achievements in technical areas of interest to NASA. By making awards based on achievements instead of proposals, NASA hopes to bring innovative solutions from academia, industry, and the public to solar system exploration and other technical challenges.

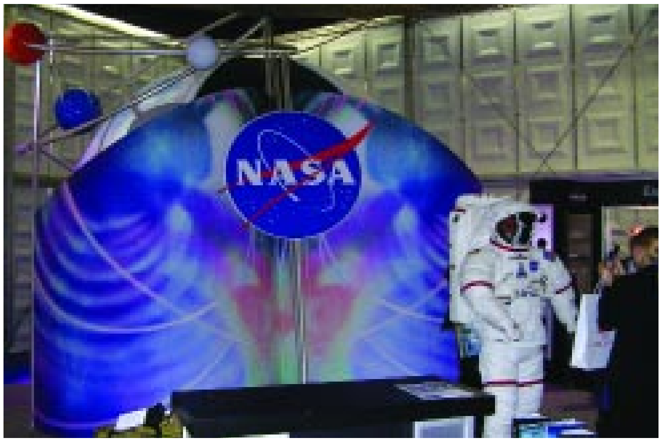

Figure 48: Spectators visit the Vision for Space Exploration exhibit at the Farnborough International Air Show.

In June, NASA held the first Centennial Challenges workshop. Participants from academia, the press, various government agencies, and industry attended to identify the categories and competitions that will be included in the Centennial Challenges program. Over 200 attendees and 30 session moderators generated ideas for future challenges in the areas of aeronautics, exploration systems, planetary systems, Earth observation, bioastronautics, and astrophysics. More information about the program and how to participate can be found at http://centennialchallenge.nasa.gov.

NASA Fact

Unlike Earth, Saturn is made mostly of hydrogen and helium. While it has heavier materials in the core, Saturn has no surface on which you could stand. Saturn is also the only planet in our Solar System that is less dense than water. If you could build a ridiculously large bathtub, Saturn would actually float in it.

As Only NASA Can: Exploration Capabilities

Goal 8

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Goal 10

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RETURN TO FLIGHT

Readying the Space Shuttle to return to flight

The *Columbia* Accident Investigation Board issued its findings in a report released in August 2003. NASA embraced the report, accepted the findings, and is currently working to comply with the recommendations. Over the past year, NASA committed itself to implementing the technical and cultural changes recommended by the Board for returning the Space Shuttle to safe flight.

Figure 49: Workers in the Orbiter Processing Facility watch closely as *Discovery*'s Forward Reaction Control System is lowered into position in the orbiter's forward fuselage nose area. The system helps *Discovery* maneuver.

To guide the return to flight effort, NASA developed the *Implementation Plan for Space Shuttle Return to Flight and Beyond*. The Plan describes how NASA will comply with the Board's 15 return to flight recommendations and includes additional actions initiated by NASA to raise the bar in Shuttle performance and safety. NASA released the plan in September 2003 and periodically updates it to record the progress being made toward a safe return to flight.

The Return to Flight Task Group, co-chaired by veteran astronauts Thomas Stafford and Richard Covey, is assessing NASA's implementation of the Board's recommendations and other technical issues. In FY 2004, the Task Group agreed to conditionally close out five of the Board's 15 recommendations (see Table 1 below). By conditionally closing out a recommendation, the Task Group affirms that NASA has responded adequately to the specific recommendation, but the final close-out is dependent upon the delivery of final information and the assurance by NASA that it will keep the Task Group up-to-date on any new developments pertaining to those recommendations. NASA is on track to close out the remaining ten recommendations by the end of 2004.

Figure 50: The *Columbia* Accident Investigation Board recommended developing a capability to inspect and perform emergency repairs to the Shuttle's Thermal Protection System in case of damage. NASA continues to develop capabilities to make on-orbit repairs to the exterior of the Shuttle. In this photo, NASA technicians train with a silicon-based "patch" that can be injected into a damaged section of the shuttle's exterior. This material will then be smoothed out to reduce turbulence during re-entry.

As the year progressed, the pace of preparations for return to flight picked up. Space Shuttle *Discovery* is being readied for the next mission, and all three orbiters are going through processing at NASA's Kennedy Space Center with new modifications being made to the Shuttles' external tanks and Thermal Protection Systems (the heat-resistant tiles that line the Shuttle and protect it from the heat of re-entry into Earth's atmosphere). When *Discovery* lifts off, it will fly with new safety improvements and modifications to enhance vehicle monitoring during flight, including 88 wing leading-edge sensors to monitor acceleration, impact, and temperature and a digital camera to document the external tank as it separates from the Shuttle. In addition, NASA crews performed more than 100 modifications on *Discovery*, including adding a multi-functional electronic display system, or "glass cockpit."

Table 1: NASA's return to flight recommendations accomplished in FY 2004.

Return to Flight Recommendation		Action	Status
3.3-1	Develop and implement a comprehensive inspection plan to determine the structural integrity of all Reinforced Carbon-Carbon system components. This inspection plan should take advantage of advanced non-destructive inspection technology.	The Space Shuttle program is pursuing inspection capability improvements using newer technologies to allow comprehensive nondestructive inspection of the Reinforced Carbon-Carbon outer coating and internal structure, and without removing it from the vehicle.	Conditionally closed by Stafford-Covey Task Group
6.3-2	Modify the Memorandum of Agreement with the National Imagery and Mapping Agency to make the imaging of each Shuttle flight while on orbit a standard requirement.	NASA has concluded a Memorandum of Agreement with the National Imagery and Mapping Agency (subsequently renamed the National Geospatial-Intelligence Agency) and has initiated discussions with other agencies to explore the use of appropriate national assets to provide for on-orbit assessments of the condition of each Orbiter vehicle.	Conditionally closed by Stafford-Covey Task Group
4.2-3	Require that at least two employees attend all final closeouts and intertank area hand-spraying procedures.	NASA has established a TPS verification team to verify and validate all future foam processes. In addition, the Material Processing Plan will define how each specific part closeout on the External Tank will be processed. Additionally, the Shuttle Program is documenting the requirement for minimum two-person closeouts for all major flight hardware elements (Orbiter, External Tank, Solid Rocket Booster, Solid Rocket Motor, extravehicular activity, vehicle processing, and main engine).	Conditionally closed by Stafford-Covey Task Group
4.2-5	Kennedy Space Center Quality Assurance and United Space Alliance must return to the straightforward, industry-standard definition of "Foreign Object Debris" and eliminate any alternate or statistically deceptive definitions like "processing debris."	The Kennedy Space Center has completed work to establish a revitalized program for identifying and preventing foreign object debris that surpasses the CAIB's recommendation.	Conditionally closed by Stafford-Covey Task Group
10.3-1	Develop an interim program of closeout photographs for all critical sub-systems that differ from engineering drawings. Digitize the closeout photograph system so that images are immediately available for on-orbit troubleshooting.	NASA has also created a robust system for photographing, archiving, and accessing closeout photography for the Space Shuttle. This system will allow key users across the Agency to quickly and easily access images of the Shuttle systems to make operational decisions during a mission and support postflight assessments.	Conditionally closed by Stafford-Covey Task Group

Note: For a complete listing of NASA's progress on return to flight recommendations in FY 2004, see Objective 8.1 in Part 2.

INTERNATIONAL SPACE STATION (ISS)

Expeditions 7, 8, and 9 continue to make progress toward a future of exploration

Throughout the fiscal year, Expeditions 7, 8, and 9 kept the International Space Station and its experiments running smoothly and conducted a number of spacewalks to expand and improve the Station.

Throughout their stay onboard, crewmembers served as the test subjects for many of the experiments (as all Station crews do). These human life sciences experiments are crucial to learning how to keep people healthy, safe, and productive in environments with gravity levels different than Earth's. One experiment required crew members to wear special pairs of Lycra cycling tights fitted with sensors that measure how much weight and stress astronauts' legs and feet endure on a

NASA Highlight:
IInternational Space Station (ISS) Science Looks to Mars

Can humans live on Mars? How do we overcome the challenges associated with the human exploration of Mars? Researchers on Earth are using several experiments aboard the ISS to study health and safety issues.

Space travelers living on Mars for extended periods will need to grow plants to provide food and generate oxygen. But, the decreased gravity and low atmospheric pressure environment will stress the plants and make them hard to grow. Onboard ISS, astronauts have become farmers in space using greenhouses in the Station's Destiny Laboratory and Zvezda Service Module to grow plants in a controlled environment. Station crews tend the plants, photograph them, and harvest samples for return to Earth. Researchers will use the resulting data to develop new techniques for successfully growing plants in space.

NASA also is concerned about health hazards posed by space radiation. A spacecraft bound for Mars will be exposed to substantial amounts of radiation, and it will have to protect the humans inside from exposure. On the ISS, sensors inside the crew areas monitor radiation levels, and researchers use the ISS to test materials that could be used to protect Mars-bound spacecraft and crews.

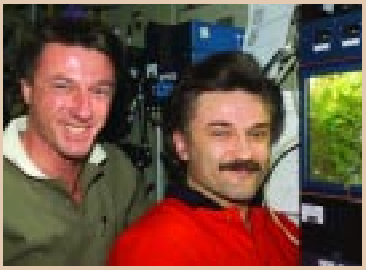

Figure 51: Expedition 8 crewmembers C. Michael Foale (left) and Alexander Kaleri pose on April 12, 2004, beside the pea plants they have grown in the LADA-4 greenhouse as part of the Russian BIO-5 Rasteniya-2 (Plants-2) experiment.

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Figure 52: Astronaut Foale wearing special tights to measure muscle usage in space.

typical day in space. Since the human body is designed to function in Earth's gravity, placing weight and some amounts of stress on limbs helps maintain muscle strength and bone density. This experiment will provide a better understanding of the bone and muscle mass loss experienced by astronauts in near-weightlessness. This research also will help researchers understand and treat the effects of osteoporosis and other illnesses and injuries that attack limb strength on Earth.

The International Space Station also provided a laboratory for several experiments designed to improve materials processing on Earth. The Pore Formation and Mobility Investigation, for example, studied bubbles that form in molten materials. When scientists melt metals on Earth, bubbles that form in the material can rise to the surface and pop. The bubbles that do not escape before the metal hardens leave behind pores, like holes in Swiss cheese, that weaken the final product. In space, the weightless environment stops the bubbles from rising and traps them inside the material. The Pore Formation and Mobility Investigation used this opportunity to look at how bubbles form and move by physical forces that are normally hidden by gravity once the material is melted. Their findings will help researchers develop methods to alleviate the problem both in space and on Earth.

In addition to maintaining the International Space Station and its experiments, the crews also continued to observe and photograph natural and man-made changes on Earth. Crew photographs revealed both changes in Earth's surface over time and more fleeting events, like storms, floods, fires, and volcanic eruptions. In August and September, the Expedition 9 crew, using a handheld digital camera mounted to the outside of the Station, captured still images and video of Hurricanes Bonnie, Charley, Frances, and others as they swept out of the Atlantic and onto the Eastern U.S. seaboard. Images from the Station also provide scientists on Earth with vital, real-time information

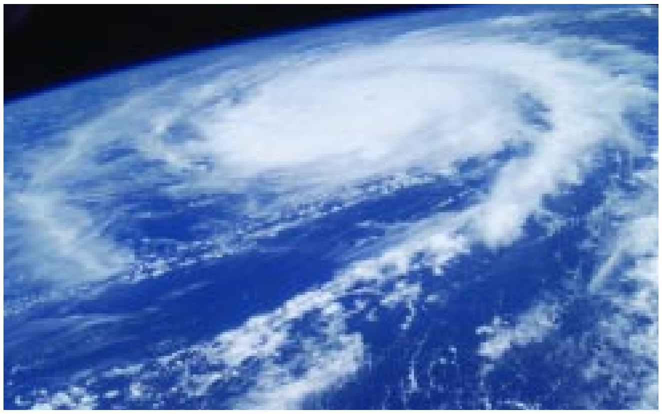

Figure 53: Astronaut Mike Fincke took this photo of Hurricane Frances while aboard the ISS as he flew 230 miles above the storm on, Aug. 27, 2004. At the time, Frances was about 820 miles east of the Lesser Antilles in the Atlantic Ocean.

on hurricane positions and potential danger, information needed to better understand and protect the planet and its inhabitants.

PREPARING FOR EXPLORATION

Since January 2004, NASA has worked to align itself with the new Vision for Space Exploration. From the creation of an Exploration Mission Directorate to the continuation of important research into the effects of space travel on the human body, NASA is readying itself for a bold adventure beyond Earth orbit.

Navigating the path to exploration

This year, NASA began charting a new path of exploration throughout the solar system by consolidating exploration-related capabilities and defining the stepping stones that will allow the Agency's explorers to reach farther than ever.

Some of the advances made this year include:

- Crafting and publishing a strategy for the newly-created Exploration Systems Management Directorate. The strategy describes the methodologies that NASA will develop, new capabilities, and supporting research and technologies that will enable humans to explore the Moon, Mars, and beyond.
- Molding requirements for developing the Crew Exploration Vehicle that will be used to transport crews to the Moon and beyond. Through competitive processes, NASA selected 11 contracting teams from industry and universities that are partnering with NASA in the formulation and refinement of concepts for sustained exploration on the Moon and the design of the Crew Exploration Vehicle.
- Initiating competitive processes to redirect NASA's exploration research and technology portfolio in support of the Vision for Space Exploration. NASA received thousands of ideas for new avenues of research involving: advanced materials and structural concepts; space communications and computing; autonomous, intelligent systems; high energy space power and propulsion systems; and lunar and planetary surface operations. From these ideas, NASA invited several hundred submitters to send in formal proposals, and the Agency awarded more than 100 new research grants. Principal Investigators from all types of U.S. research institutions, including NASA Centers, industry, and universities, are leading the new research.
- Advancing the development of the Jupiter Icy Moons Orbiter (JIMO), an ambitious mission to orbit three planet-sized moons of Jupiter—Callisto, Ganymede, and Europa—that may harbor vast oceans beneath their icy surfaces. NASA's Galileo spacecraft found evidence that these subsurface oceans may exist, a finding that ranks among the major scientific discoveries of the Space Age. The JIMO mission would orbit each of these moons for extensive investigations of their makeup, history, and potential for sustaining life. In this fiscal year, NASA defined requirements for spacecraft development, implemented a project management structure, selected a prime contractor, and entered into an interagency agreement for nuclear reactor development with the Department of Energy's Office of Naval Reactors.

Improving human health and performance in space

As NASA prepares to go forward with the Vision for Space Exploration, the Agency continues to examine the effects of space travel on the human body. How do scientists keep astronauts safe and healthy in space? How does microgravity change the way plants or human cells grow? Finding the answers to these questions is not only important for future space travelers, but to the development of new materials and products on Earth, including some directly related to making people's lives healthier and safer.

SPINOFF SPOTLIGHT

Gearing up for the big game and more

When astronauts went to the Moon, they wore liquid-cooled garments to protect them from the Moon's extreme temperatures. The technology that protected the Apollo astronauts is now keeping athletes cool and comfortable on Earth. After years of work, doctors and sports trainers are using NASA space suit technology in the realm of sports medicine.

In 2002, researchers released their first product, a set of ergonomic wraps that provide deep tissue cooling therapy and intermittent compression. The wraps fit around commonly injured parts of the body and circulate cold water through the wrap while applying intermittent compression. Professional trainers using the system report that their athletes' recover in half the time they would expect for the injuries they commonly treat.

The research team also released a cooling system that can alleviate the symptoms associated with Multiple Sclerosis and other neurological disorders. The system consists of a hooded vest that attaches to a rechargeable control unit and features a hidden cooling system. It looks like ordinary outerwear when disconnected from the control unit.

In February 2004, the research team announced it was testing a "next-generation" cooling helmet with the Stanford University Medical Center's Stanford Stroke Center.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html*

Credit: CoolSystems, Inc.

Figure 54: A hooded body wrap can bring down core body temperature to alleviate the symptoms of Multiple Sclerosis and other neurological disorders or to treat heat exhaustion or heat stroke.

As Only NASA Can: Exploration Capabilities

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NASA Fact

In the mid-1960s the Jet Propulsion Laboratory developed digital image processing to allow computer enhancement of Moon pictures. This technology is now used by doctors and hospitals to record images of organs in the human body. Two of the most widely used techniques are computer-aided tomography (CATScan) and magnetic resonance imaging (MRI).

Credit: Brookhaven National Laboratory

Figure 55: A researcher sets up an experiment at NASA's Space Radiation Laboratory. Such ground-based studies play an important role in understanding space radiation and finding ways to reduce or prevent its effects on astronauts.

Space radiation produced by the Sun and other galactic sources is more dangerous, and hundreds of times more intense, than normal radiation sources (e.g., medical X-rays or normal cosmic radiation) experienced on Earth. When the intensely charged particles found in space strike human tissue, they can cause cell damage, genetic changes, and may even lead to cancer. In FY 2004, NASA research teams made significant advances in the area of space radiation and its effects on the human body. During experiments at the NASA Space Radiation Laboratory located at Brookhaven National Laboratory in New York, a NASA research team obtained some of the first direct evidence of how space radiation deposits energy in deoxyribonucleic acid (DNA), the molecule of life. In the experiment, human skin cells were irradiated with gamma-rays (a high-energy version of X-rays commonly used on Earth) and with one type of high-energy charged particles like those found in space radiation. The research team will use the results to understand how space radiation damages cells and to develop countermeasures that mitigate radiation effects.

More than 100 tasks are being funded by the NASA science community including a study to define the risks of tissue damage to astronauts' brains and eyes—damage associated with exposure to galactic cosmic ray particle irradiation during a proposed space mission to Mars. By funding radiation experiments like this, NASA continues to bring new scientists into the NASA research community and reduce the estimated radiation risks to humans.

CLOSING THE MILES BETWEEN US

NASA research and technology is increasing communications between scientists, astronauts, and many groups outside NASA. From remotely monitoring the health of explorers and diagnosing injury to ensuring access to critical mission data, NASA teams work every day to make sure that communication and information transfer go smoothly between users.

NASA technology makes it to the National Hockey League

Ultrasound techniques developed by NASA to examine International Space Station crewmembers may soon find another use helping to treat medical emergencies on Earth. The probability of a crewmember developing a serious medical condition increases on long-duration missions. Although doctors on Earth routinely use X-ray and computerized tomography scans (also known as CT scans) to diagnose medical conditions on Earth, these diagnostic tools are not available on the Station due to their excessive weight and power requirements. Ultrasound is a fast and safe technique that uses sound waves to gain information about medical conditions ranging from gallbladder disease to kidney stones. NASA originally developed portable ultrasound machines to examine crewmembers on the International Space Station. Recently, the Detroit Red Wings of the National Hockey League tested portable ultrasound technology techniques to diagnose player injuries in the team's locker room as an alternative to transporting athletes to Henry Ford Hospital for an X-ray, CT scan, or magnetic resonance imaging.

A portable ultrasound device was placed in the team's locker room and connected to an ultrasound workstation at Henry Ford Hospital. A radiologist, serving as the remote expert, worked with the NASA research team to guide the Red Wings' trainers who performed the ultrasound tests on a shoulder, ankle, knee, hand, and foot. The resulting high-quality test images were transmitted to the hospital and could have been used to confirm or exclude the existence of injuries to these areas.

Monitoring the health of scientists and explorers

A lightweight, portable device called a LifeGuard developed by NASA scientists is enabling physicians to monitor the health and safety of explorers in remote locations on Earth. NASA originally designed the compact, wearable system to monitor astronauts' health while they are in space. It allows real-time monitoring of vital functions like heart rate, blood pressure, electrocardiogram, breathing rate, and temperature. It also measures human movements in three dimensions. In autumn 2003, the wireless system watched over the vital signs of several expedition members who sampled soils and water from the world's highest alpine lake, nearly 20,000 feet up the Licancabur volcano, on the border between Chile and Bolivia. The LifeGuard units sent real-time vital signs from subjects at the volcano to NASA scientists by satellite, demonstrating the monitor's ability to work in an extreme environment and its potential use in telemedicine where doctors practice "long-distance" medicine using patient data sent from remote locations.

Figure 56: Expedition 8 Commander and Science Officer Michael Foale participates in a mission training session in ultrasound technology at JSC. Foale uses an ultrasound wand on a rescue dummy as Flight Engineer Alexander Kaleri observes.

The LifeGuard is about the size of a computer mouse and is worn around the waist. It can track human physiologic functioning as people go about their normal routines without tethering them to a stationary device. Future uses of the system could include diagnosing sleep disorders, heart disease, or unsteady gait in the elderly.

NASA enables scientists to work together while miles apart

For the first time, researchers thousands of miles apart can study laboratory specimens simultaneously by remotely operating NASA's new "super magnifying glass," using Remote Scanning Electron Microscopy technology. NASA originally developed the technology to allow scientists to help NASA solve problems encountered by astronauts during long-duration space flights. In contrast to conventional microscopes that use light waves, this device uses electrons to magnify details of tissue from 10 to 100,000 times. This super-dissecting microscope illuminates the sample with a great depth of field and produces three-dimensional, high-resolution images. All that researchers need is a suitable Web browser and network access to connect to the instrument. A remote-control system on the microscope enables multiple researchers to perform real-time simultaneous analysis of the tissues under investigation without having to incur travel costs.

SPINOFF SPOTLIGHT

"Contact" in Space Leads to New Lenses

Although gravity has its advantages in keeping humans balanced and grounded on Earth, scientists often find that they are at a disadvantage when trying to conduct research under its powerful, pulling influence. That's why scientists prefer to perform their research in the near-weightlessness of Earth orbit where solids, liquids, and gases behave much differently.

In 1993, a company teamed with NASA to perfect a process for developing contact lenses. During experiments flown on the Space Shuttle, the team exposed the materials used in the lenses to low gravity to gain a better understanding of how polymers—the large molecules that make up plastics—are formed. This is important to lens manufacturers since permeable plastics are better for extended-wear contacts because they allow more oxygen to pass through the lens, keeping the eye healthier.

In 2004, the company released a rigid contact lens that is gas permeable, resistant to deposits, and less likely than soft contact lenses to harbor bacteria. Their rigid shape makes them easier to handle than soft lenses and allows them to retain their shape longer, providing crisper vision.

The company also used what it learned from the Shuttle experiments to invent a contact lens that nonsurgically reshapes the cornea during sleep. The patient removes the lenses the next day to experience a temporary reduction of near-sightedness, with or without moderate astigmatism.

Extensive studies of the new lens, leading to its approval by the Food and Drug Administration, showed that almost 70 percent of the patients who wore them achieved 20/20 vision or better and more than 93 percent achieved 20/32 vision or better.

Read more about this story in Spinoff 2004 *available on the Internet at http://www.sti.nasa.gov/tto/index.html.*

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NEW TECHNOLOGIES

Developing revolutionary capabilities through autonomous air vehicles research

A number of activities, including Earth science, homeland security, telecommunications, and even traffic reporting, require aircraft services for an extended period of time, but crew support can be prohibitively expensive. NASA is enabling revolutionary capabilities to meet the needs of these activities by developing and demonstrating technologies for long-endurance, uncrewed aerial vehicles (UAVs) that eventually may aid space missions by providing communication support and other automated services. However, here are three major technological challenges that must be resolved before UAVs can meet their full potential:

- Solar-powered UAVs must be able to operate over several diurnal (day/night) cycles;
- UAVs must be able to operate routinely and safely in the national airspace; and
- UAVs must become fully autonomous, requiring minimal monitoring by ground crews. This year, NASA made significant advances in each of these areas.

To enable long-endurance (i.e., multi-day) missions, NASA's Glenn Research Center and partner Aerovironment successfully built and tested a flight-prototype of a regenerative energy storage system under laboratory conditions. Regenerative storage systems, which would collect solar-electric power during the day and store it for use at night, will allow UAVs to remain in flight at high altitudes for 30 days or more.

Figure 57: The remotely-piloted Altair uncrewed aerial vehicle was developed for NASA by General Atomics Aeronautical Systems, Inc. as a long-endurance, high-altitude platform for development of UAV technologies and environmental science missions.

Routine access to U.S. airspace will enhance potential use of remotely operated aircraft, including traffic monitoring, weather forecasting, and remote sensing. This year, NASA and its partners from the DoD, FAA, and six aerospace firms initiated a project to enable high-altitude, long-endurance, remotely operated aircraft to operate within U.S. airspace. The project team made significant progress toward validating a set of requirements for these vehicles to gain access to U.S. airspace at and above 40,000 feet.

NASA also is developing new ways to make UAVs operate autonomously with minimal ground crew support. These autonomous flyers must be able to manage their resources (e.g., fuel), successfully handle changing flight plans, and recover from internal and external disturbances (e.g., turbulence). This year, NASA validated currently existing UAV technology and identified future UAV technology requirements through simulations of architectures, technologies, and interfaces necessary for successful flight.

NASA develops system to computerize silent, "subvocal speech"

Astronauts sometimes have to work under conditions in which they cannot easily talk or type out a message on a communication device. NASA scientists are working on a solution to computerize human, silent reading, turning subvocal speech into signals that can be recognized by a computer.

In preliminary experiments this year, NASA scientists found that small, button-sized sensors stuck under the chin and on either side of the "Adam's apple" can gather nerve signals and send them to a processor. A computer program then translates the signals into words. Eventually, such subvocal speech systems could be used in spacesuits, in noisy places like airport towers to capture air-traffic controller commands, or even as part of traditional voice-recognition programs, like those that assist handicapped computer users, to increase accuracy.

Credit: NASA/D. Hart

Figure 58: NASA scientist Chuck Jorgensen models the sensors, worn under the chin and on either side of the "Adam's apple," used to gather nerve signals that control speech.

In their first experiment this year, scientists "trained" special software to recognize six words and 10 digits that the researchers repeated subvocally. Initially, the software was able to recognize approximately 92 percent of the words silently spoken. The first sub-vocal words the system "learned" were "stop," "go," "left," "right," "alpha," and "omega," and the digits "zero" through "nine." Silently speaking these words, scientists conducted simple searches on the Internet by using a number chart representing the alphabet to control a Web browser program.

Further work is being done to develop and control a mechanical device using a simple set of sub-vocal commands that could assist astronauts if they lose strength over long-duration space missions.

NASA Fact

Have you ever heard of "Armalcolite"? Armalcolite is a mineral that was discovered at Tranquility Base on the Moon by the Apollo 11 crew. It was named for ARMstrong, ALdrin and COLlins, the three Apollo 11 astronauts.

Legislative Requirements and Management Controls

NASA's annual Performance and Accountability Report satisfies a number of 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. In addition, a number of other legislative acts, bulletins and circulars from the Office of Management and Budget, and Federal regulations mandate that all Federal agencies, including NASA, include certain statements and information in this Report.

NASA is in compliance with all Performance and Accountability Report reporting 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.

Legislative Act	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 IT security at government agencies.	NASA maintains an ongoing IT Security Program that meets Federal requirements. With FY 2004 expenditures of approximately $100 million, this ongoing program includes activities related to IT 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 the Administrator's Message.
Federal Managers Financial Integrity Act of 1982 (FMFIA)	Provide a report on the health and integrity of an agency's financial and management systems and its ability to safeguard against waste, loss, unauthorized use, or misappropriation of funds.	The FMFIA statement is included in the Administrator's Message.
Government Performance and Results Act of 1993	Provide information on an agency's actual performance and progress in achieving the goals in its strategic plan and performance budget.	Parts 1 and 2 of this document meets 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.	The Appendices contain NASA's Inspector General's report on serious management challenges and follow-up audit actions.

Legislative Act	Requirement	Comments
Office of Management and Budget Bulletin 01-09: Form and Content of Agency Financial Statements	An agency's financial statements should include the management's discussion and analysis.	Part 1 of this document should be considered the Management's Discussion and Analysis.
	An agency's financial statements should include: basic statements and related notes, required supplementary stewardship information, and required supplementary information.	Part 3 of this document contains NASA's financial statements and all related notes and information.
Office of Management and Budget Circular A-11: Preparation, Submission and Execution of the Budget	A comparison of actual performance with planned performance as set out in the performance goals the annual performance plan.	Performance tables under each Objective in Part 2: Detailed Performance Data provide the original performance goal and the rating that NASA received on that goal. Narrative discussion on multi-year goals, called Outcomes, is also included.
	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 the "Challenges" table in Part 2: Detailed Performance Data.
	An evaluation of your performance budget for the current fiscal year, taking into account the actual performance achieved.	There are no changes to the President's FY 2005 Budget Request.
	Actual performance information for at least four fiscal years.	Performance tables in under each Objective 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.	OMB's PART assessments will be included with the President's Budget, which will be released in February 2005. NASA programs to be assessed include: Structure and Evolution of the Universe, Sun-Earth Connection, Earth Systems Science, Aeronautics Technology, Education Programs, Space Flight Support, and International Space Station.
Reports Consolidation Act of 2000	Combine an Agency's Performance Report with its Accountability Report.	This document 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 the Administrator's Message.
	Include Office of Inspector General serious management challenges.	Serious management challenges are referenced in the Administrator's Message and are included, in full, as Appendix I.

Part 2

Detailed Performance Data

Introduction to NASA's Detailed Performance Data

The four-part Mission Statement and ten Strategic Goals in NASA's Strategic Plan provide the framework for the Agency's annual performance plan that is part of NASA's Integrated Budget and Performance Document. As in previous years, NASA's FY 2004 performance plan included long-term Performance Objectives and Annual Performance Goals (APGs). But, in FY 2004, NASA addressed the difficult task of measuring annual performance against long-term research and development goals by adding a new set of mid-range measures called Performance Outcomes to help the Agency track and evaluate progress at a more meaningful level. These Outcomes enable NASA to focus and report on multi-year efforts more accurately and to provide a clearer picture of planned and actual performance on an annual and multi-year basis.

NASA's Mission	NASA's Strategic Goals
To Understand and Protect our Home Planet	Goal 1: Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.
	Goal 2: Enable a safer, more secure, efficient, and environmentally friendly air transportation system.
	Goal 3: Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.
To Explore the Universe and Search for Life	Goal 4: Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.
	Goal 5: Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.
To Inspire the Next Generation of Explorers	Goal 6: Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.
	Goal 7: Engage the public in shaping and sharing the experience of exploration and discovery
As Only NASA Can: Exploration Capabilities	Goal 8: Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.
	Goal 9: Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.
	Goal 10: Enable revolutionary capabilities through new technology.

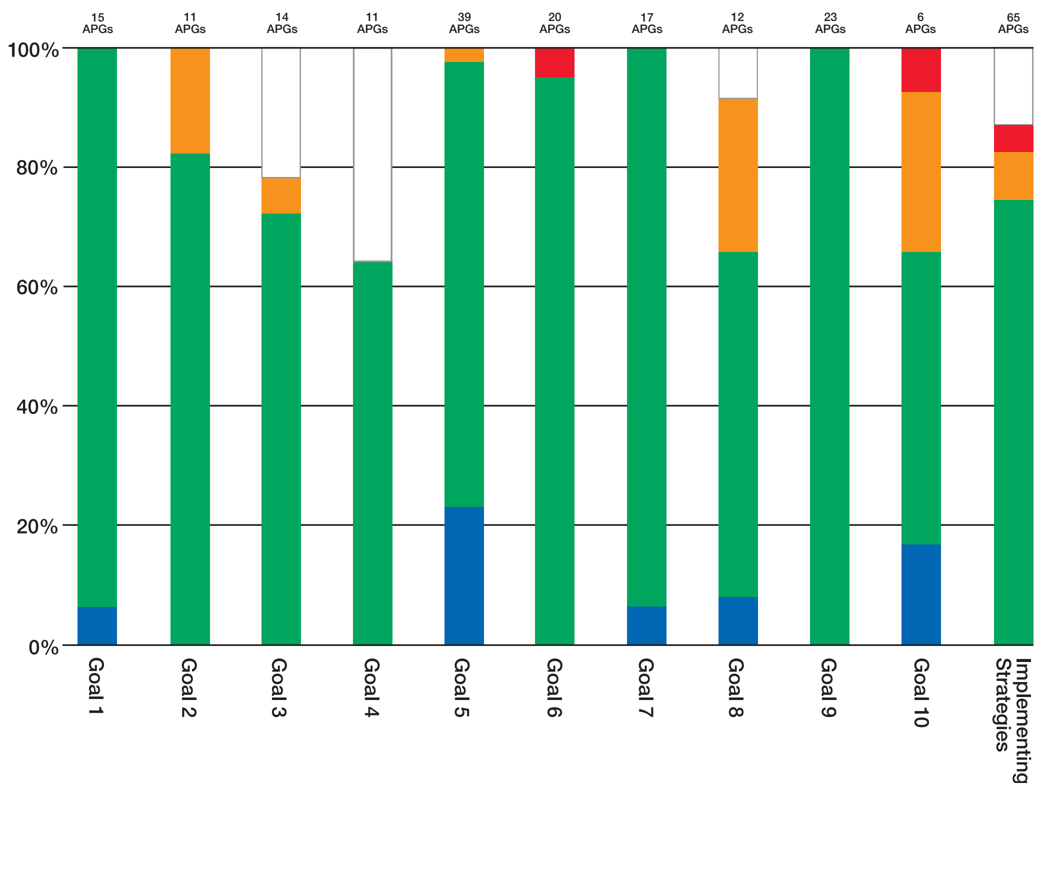
Part 1 of this report, "Management Discussion and Analysis," presented NASA's performance achievement highlights by Mission and Strategic Goal. Part 2 of this report, "Detailed Performance Data," describes each of the Performance Objectives within these Goals and provides a detailed performance report and color rating for each Performance Outcome. Part 2 also includes color ratings for each APG, as well as APG trend data for up to four years, where applicable. (Performance ratings for NASA's Implementing Strategies, including three types of Uniform Measures, are located at the end of Part 2, preceded by a brief explanation of their purpose and organization.) Finally, Part 2 includes NASA's Performance Improvement Plan addressing all Performance Outcomes and APGs that were not fully achieved in FY 2004.

The APG and Performance Outcome ratings in Part 2 reflect NASA management's intense efforts to evaluate thoroughly and objectively the Agency's performance based on all data available as of September 30, 2004. Internal reviewers (NASA employees and managers at many levels across the Agency) reviewed the performance results and recommended APG color ratings to NASA senior officials. In addition, in many cases, external reviewers (e.g., highly qualified individuals, advisory boards, and advisory councils outside NASA) assisted in this evaluation process by reviewing the same performance results and independently recommending specific APG color ratings. Following careful assessment of all performance data and results, as well as the color rating recommendations of both the internal and external reviewers, NASA senior management officials assigned color ratings to each APG using the following color rating criteria:

- Blue: Significantly exceeded APG
- Green: Achieved APG
- Yellow: Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
- Red: Failed to achieve APG, do not anticipate completion within the next fiscal year.
- White: APG was postponed or cancelled by management directive.

Next, NASA management, again aided in many cases by recommendations from internal and external reviewers, assigned color ratings to each Performance Outcome. (Note: Performance Outcome ratings are not averages of APG ratings, and they are not based solely on the Agency's performance in the current fiscal year. Performance Outcome ratings are based on NASA's progress toward achieving its multi-year goal. Therefore, it is possible to have APGs rated Yellow or Red, and still be on target to achieve a Performance Outcome as stated.) NASA senior management officials assigned color ratings to each Performance Outcome using the following color rating criteria:

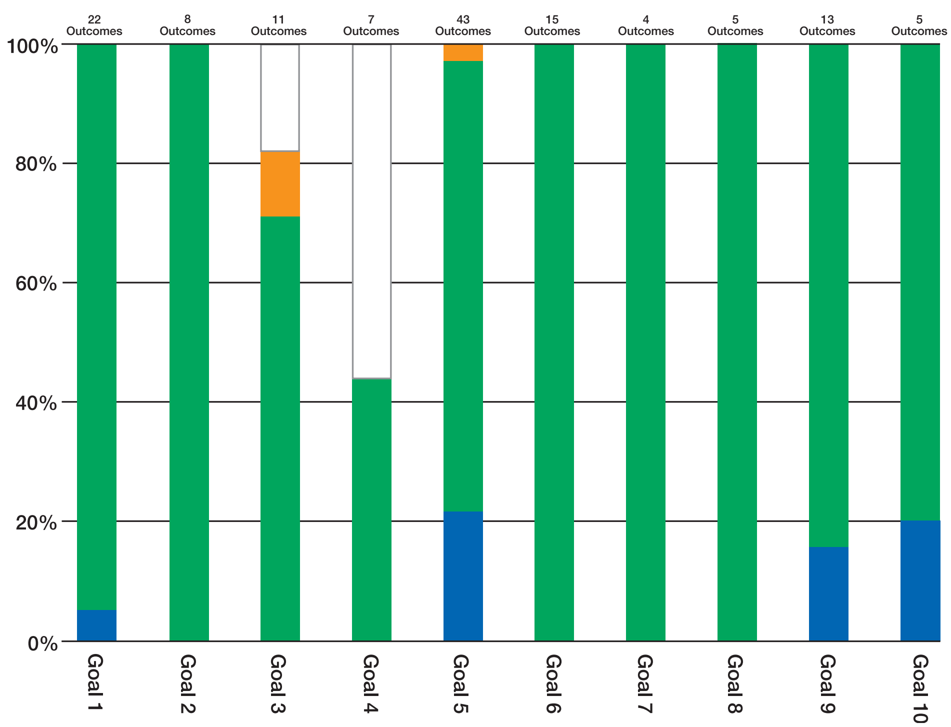
Figure 59 provides a summary of NASA's FY 2004 APG performance by Strategic Goal.



- Blue: Significantly exceeded all APGs. On track to exceed this Outcome as stated.
- Green: Achieved most APGs. On track to fully achieve this Outcome as stated.
- Yellow: Progress toward this outcome was significant. However, this Outcome may not be achieved as stated.
- Red: Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
- White: This Outcome as stated was postponed or cancelled by management directive or the outcome is no longer applicable as stated based on management changes to the APGs.

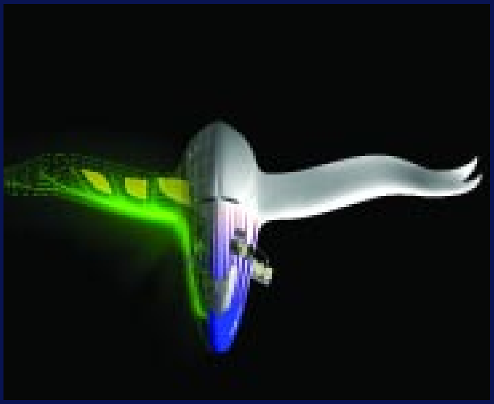
NASA is including a Performance Improvement Plan in this year's report. This Plan addresses, in detail, each APG and Performance Outcome that was not fully achieved (rated Blue or Green) in FY 2004. For each unmet Performance Outcome or APG, this Plan presents an explanation as to why the metric was not met and how NASA plans to improve performance in this metric (or why NASA will be eliminating this metric) in the future. This Plan also demonstrates how future performance improvements will enable NASA to fully achieve many Performance Outcomes in spite of current year APG ratings of Yellow or Red.

Figure 60 provides a summary of NASA's FY 2004 Outcome performance by Strategic Goal.



Mission: To Understand and Protect Our Home Planet

Goal 1: Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.



Goal 2: Enable a safer, more secure, efficient, and environmentally friendly air transportation system.

Goal 3: Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.

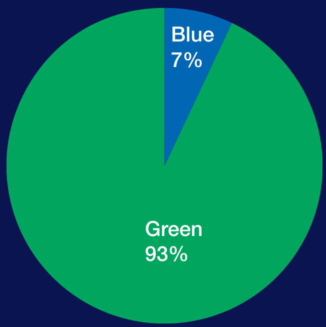
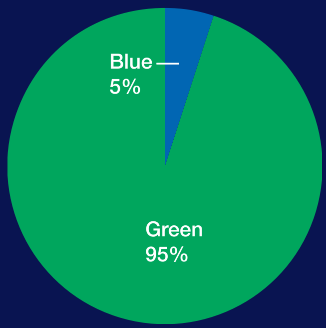


Figure 61: NASA achieved 100 percent of the APGs in Goal 1.



NASA is on track to achieve 100 percent of its Outcomes under Goal 1.

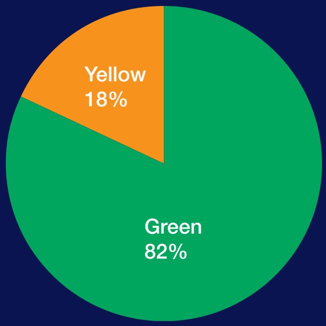
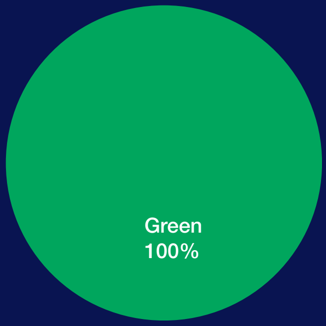


Figure 62: NASA achieved 82 percent of the APGs in Goal 2.



NASA is on track to achieve 100 percent of its Outcomes under Goal 2.

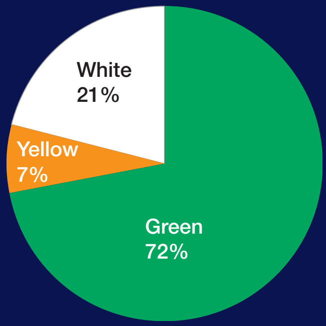
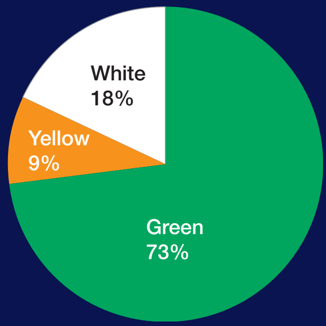


Figure 63: NASA achieved 72 percent of the APGs in Goal 3.



NASA is on track to achieve 73 percent of its Outcomes under Goal 3.

APG color ratings:

- Blue: Significantly exceeded APG
- Green: Achieved APG
- Yellow: Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
- Red: Failed to achieve APG, do not anticipate completion within the next fiscal year.
- White: APG was postponed or cancelled by management directive.

Outcome color ratings:

- Blue: Significantly exceeded all APGs. On track to exceed this Outcome as stated.
- Green: Achieved most APGs. On track to fully achieve this Outcome as stated.
- Yellow: Progress toward this Outcome was significant. However, this Outcome may not be achieved as stated.
- Red: Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
- White: This outcome as stated was postponed or cancelled by management directive or the Outcome is no longer applicable as stated based on management changes to the APGs.

Goal 1 Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.

OBJECTIVE 1.1

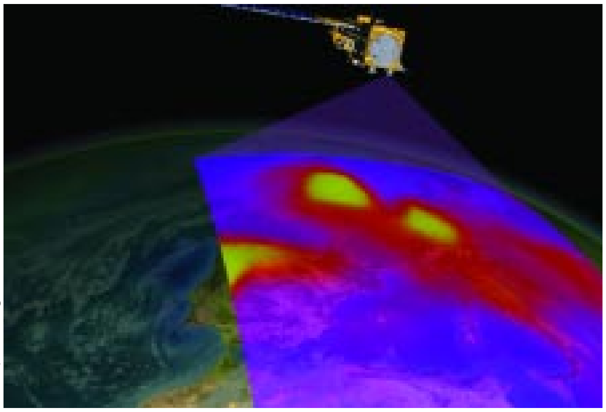
Understand how the Earth is changing, better predict change, and understand the consequences for life on Earth.

NASA Science—Ozone Recovery

A number of human-made chemicals, such as chlorine, chlorofluorocarbons, and halons, create a complex chemical reaction in the atmosphere that ultimately destroys ozone, a form of oxygen that protects Earth from the Sun's biologically harmful ultraviolet radiation. In 1987, the international community ratified the Montreal Protocol on Substances that Deplete the Ozone Layer to restrict the manufacture of these chemicals. NASA Earth science missions measure the amounts of ozone and ozone-depleting chemicals in the atmosphere to determine if this critical protective layer is recovering as ozone-depleting chemicals are phased out.

WHY PURSUE OBJECTIVE 1.1?

Earth is a dynamic place of constant change. Each change—from dramatic, fast-moving storms to slow average temperature shifts—affects our lives. The atmosphere, continents, oceans, ice, and life interact to form the complex Earth system. NASA's view from space affords researchers a unique perspective on how global change affects specific regions and how local changes have global consequences. NASA and the Agency's partners in the science community are addressing key science questions about the ever-changing Earth system. NASA pursues the answers to these questions using a systems approach that includes observation from the Agency's comprehensive suite of Earth observing satellites, research and data analysis, modeling, and scientific assessment. The results of these efforts enhance the ability of researchers to predict Earth system events and to understand what consequences these events hold for life on Earth.



Credit: NASA/Goddard Space Flight Center Scientific Visualization Studio

Figure 64: On June 19, 2004, NASA launched Aura, a next-generation Earth-observing satellite. One of several instruments on the Aura satellite is the Ozone Monitoring Instrument, a contribution of the Netherland's Agency for Aerospace Programs and the Finnish Meteorological Institute. This instrument monitors total ozone and other atmospheric parameters related to ozone chemistry and climate. In this simulation, Aura passes over Europe collecting data.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 1.1.1: Enable prediction of polar and global stratospheric ozone recovery (amount and timing) to within 25% by 2014.

This year, space-based, airborne, balloon-borne, and ground-based measurements, coupled with advanced computer modeling, significantly improved scientists' predictions of ozone loss and recovery in Earth's polar regions. New data also helped NASA researchers better understand mass and ozone exchange between the stratosphere and troposphere, helping them improve modeling of ozone distribution, sources, and sinks (reservoirs of ozone-depleting chemicals). Researchers determined that stratospheric cooling associated with global warming could hasten global ozone recovery due to the way temperature affects the rates of some ozone loss. This same cooling could lead to more severe seasonal Arctic ozone losses, and delay polar ozone recovery, because increased abundances of polar stratospheric clouds activate the chemicals responsible for ozone loss.

Outcome 1.1.2: Predict the global distribution of tropospheric ozone and the background concentration in continental near-surface air to within 25% by 2014.

NASA launched the Aura spacecraft on July 15, 2004 and Aura has already delivered new data that will advance the models required for the prediction of global tropospheric ozone. In addition, the Transport and Chemical Evolution of the Pacific mission, which used a combination of airborne and satellite instruments, produced two special issues of the Journal of Geophysical Research: Atmospheres documenting the increased understanding of how emissions from Asia affect global tropospheric ozone.

Outcome 1.1.3: Enable extension of air quality forecasts for ozone and aerosols from 24 to 72 hours by 2010.

Accurate air quality forecasts require accurate emissions data. A combination of data from satellite missions and aircraft campaigns have revealed errors in emissions inventories for tropospheric aerosols and precursor gases for tropospheric ozone. NASA is using this current data to correct these inventories.

Outcome 1.1.4: Use satellite data to help enable decreased hurricane landfall uncertainty from +/- 400 km to +/- 100 km in the three-day forecasts by 2010.

NASA researchers are making significant progress in their ability to forecast hurricane landfall. This year, using case studies, researchers demonstrated improved five-day storm track prediction and precipitation forecasts for hurricanes Bonnie and Floyd using data from the Tropical Rainfall Measuring Mission satellite's Microwave Imager and Special Sensor Microwave Imager, which are part of the Goddard Earth Observing System global data assimilation system. Additional studies by Florida State University and Langley Research Center investigators demonstrated that remotely sensed humidity profiles from suborbital platforms could improve three-day hurricane track forecasts by 100 kilometers over forecasts using traditional aircraft-based information.

Outcome 1.1.5: Use satellite data to help extend more accurate regional weather forecasting from 3 days to 5 days by 2010.

NASA developed the capability to integrate Atmospheric Infrared Sounder temperature and moisture profiles into the National Oceanic and Atmospheric Administration's (NOAA's) Forecast System Laboratory Local Analysis and Prediction System. Researchers used profiles generated over land and water at 45-kilometer resolution to initialize the Pennsylvania State University/National Center for Atmospheric Research MM5 model system. Preliminary experiments showed that the profiles had a positive impact on subsequent forecasts; forecasts of temperature and moisture were extended 17 hours, as determined by NOAA's National Weather Service network. Similarly, data from the Tropical Rainfall Measuring Mission Microwave Imager had a positive impact on Atlantic tropical storm intensification forecasts; they were extended to 72 hours when introduced into an experimental version of NOAA's Statistical Hurricane Prediction Scheme model.

Outcome 1.1.6: Develop projections of future atmospheric concentrations of carbon dioxide and methane for 10–100 years into the future with improvements in confidence of >50% by 2014.

Researchers compared satellite observations of fires, weather, and vegetation characteristics against measurements of atmospheric carbon dioxide and methane. The results revealed higher fire emissions during hotter and drier El Niño years. Fires cause most of the increases in atmospheric carbon dioxide and methane. Scientists are modifying their models to incorporate this new understanding of mechanisms controlling annual variations in carbon emissions. These modifications will directly improve the capability for projecting future atmospheric carbon dioxide and methane concentrations.

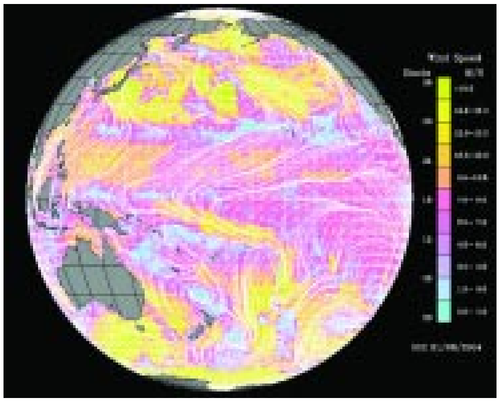


Figure 65: This image uses data from the QuikSCAT instrument on SeaWinds to show winds on the surface of the Pacific Ocean on January 8, 2004. NASA scientists are using satellite data to create three-dimensional models, which include temperature, salinity, and current, that help them forecast ocean conditions up to three days in advance.

Outcome 1.1.7: By 2014, develop in partnership with other agencies, credible ecological forecasts that project the sensitivities of terrestrial and aquatic ecosystems to global environmental changes for resource management and policy-related decision-making.

NASA analyzed results from its Carnegie–Ames–Stanford Approach (CASA) model (developed by scientists from NASA's Ames Research Center, the Carnegie Institute, and Stanford University) and CASA–Carbon Query and Evaluation Support Tools, developed for use in the Invasive Species Forecasting System. The model also identified forest and agricultural sinks (reservoirs that absorb released carbon from another part of the carbon cycle) for atmospheric carbon dioxide. Through an Internet interface, researchers can now use the NASA CASA model and CASA–Carbon Query and Evaluation Support Tools to support ecosystem decisions and carbon management applications.

Outcome 1.1.8: Report changes in global land cover, productivity, and carbon inventories with accuracies sufficient for use in the food industry, in evaluating resource management activities, and in verifying inventories of carbon emissions and storage.

The world's oceans, soil, and above-ground biomass absorb approximately 50 percent of the carbon emitted into the atmosphere each year, providing a natural—and crucial—way to manage atmospheric carbon dioxide. NASA analyzed satellite records of worldwide surface seawater chlorophyll concentrations, and the results show that chlorophyll production in the North Pacific and North Atlantic gyres (circular ocean currents) vary from season to season, but generally expanded from 1996 through 2003. Little change occurred in the South Pacific, South Atlantic, and southern Indian Ocean gyres. In addition, the Large Scale Biosphere–Atmosphere Experiment in Amazonia provided data on current land cover changes and its effect on the carbon balance in the Amazon. These results are helping scientists improve their estimates of global ocean carbon storage dynamics, verify forest inventories, and update estimates of tropical carbon emissions dynamics.

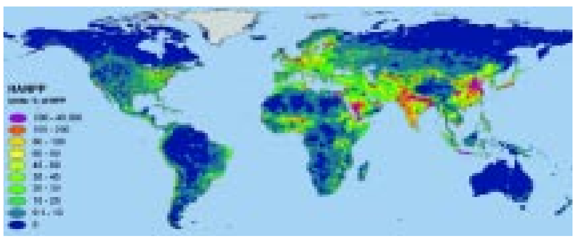


Figure 66: This figure shows human appropriation of net primary production (NPP) as a percentage of the local NPP. The map provides insight into the percent of plant resource used by people in an area compared to the amount of plant resource that is actually available locally. The data used for this map, created as part of a project between NASA and the World Wildlife Fund, was processed by NASA but derived from the National Oceanic and Atmospheric Administration's Polar Orbiting Environmental Satellites.

Outcome 1.1.9: Enable development of seasonal precipitation forecasts with >75% accuracy by 2014.

Through the North American Land Data Assimilation System, researchers now can model the land surface of the continental United States to within 1/8th-degree resolution for a period of 25 years. They achieved this high degree of accuracy by using multiple models. The Global Land Data Assimilation System project and Global Soil Wetness Project II have extended this work to include the entire globe. The products of these projects were used in the Global Land–Atmosphere Coupling Experiment, which indicated areas around the world where having soil moisture information would improve researchers' ability to predict precipitation. Scientists also used recent NASA data from the Gravity Recovery and Climate Experiment satellite to provide new information about large-scale (more than 500,000 square-kilometer) changes in total water storage. They are integrating this data with seasonal prediction systems to reduce errors in forecasting seasonal precipitation.

Outcome 1.1.10: Improve estimates of the global water and energy cycles by 2012 to enable balancing of the global and regional water and energy budgets to within 10%.

The Coordinated Enhanced Observing Period, an international program to establish an integrated global observing system for Earth's water cycle, is using NASA's Global Land Data Assimilation System data to identify gaps in observations and understanding that prevent researchers from developing better models of the water and energy cycle budget (the total amount of water and energy that cycles between land, water, and the atmosphere). In addition, NASA's Land Information System project developed a one-kilometer-resolution global land surface modeling platform that eventually will enable researchers to validate (and improve their ability to identify) deficiencies in global water and energy cycle budget balances and to improve estimates of local, regional, and global budgets to below 10 percent.

Outcome 1.1.11: Reduce uncertainty in global sea level change projections by 50% by the year 2014, and include regional estimates of deviation from global mean.

This year, scientists successfully modeled the state of the ocean through NASA's Estimating the Circulation and Climate of the Ocean project. Comparisons of data from different models show that scientists are making significant progress in both their overall understanding of the physical state of the ocean and their ability to predict ocean changes. This project is now running a 10-year model of global ocean circulation at one-quarter degree resolution.

Outcome 1.1.12: Enable 10-year or longer climate forecasts by the year 2014 with a national climate modeling framework capable of supporting policy decision-making at regional levels.

This year, NASA developed new Atmosphere-Ocean Global Climate Models that make contributions to the upcoming third assessment, reported in the Intergovernmental Panel on Climate Change, a group that assesses scientific, technical, and socio-economic information relevant for the understanding of climate change. NASA scientists will analyze assessment runs and compare them to results from the Geophysical Fluid Dynamics Laboratory and the National Center for Atmospheric Research climate runs. These activities will set the stage for multi-agency collaborative development, testing, and assimilation of data for process validation. This is the first archive of global cloud systems developed in a cloud object database with attendant atmospheric state parameters. It is a key resource for testing cloud models used in climate systems models.

Outcome 1.1.13: Enable 30-day volcanic eruption forecasts with > 50% confidence by 2014.

This year, NASA used geodetic global positioning systems to measure volcanic inflation and earthquake fault motion to validate the development of space geodetic technology, hardware, algorithms, and scientific research of the past 20 years. The Gravity Recovery and Climate Experiment (GRACE) measured the accumulation of stress along convergent plate boundaries that has lead to some of the largest earthquakes on the Earth's surface. GRACE data provided the first confirmation that time variable gravity could be measured at high resolution far exceeding any equivalent land surface measurements, and quantitatively estimated monthly water accumulation within the South American Amazon and Orinoco river basins. GRACE data and related algorithms have improved the ability to resolve the mass flux dynamics of the Earth System including the ultimate measurement of regional strain accumulation at plate boundaries. This activity was part of NASA's participation in "Restless Planet," an initiative of the multi-agency EarthScope program that applies observational, analytical, and telecommunications technologies to investigate the structure and evolution of the North American continent and the physical processes controlling earthquakes and volcanic eruptions. In addition, NASA accumulated over 200 Interferometric Synthetic Aperture Radar interferograms to track the inflationary cycle of Mount Etna over the past 13 years. (During inflationary cycles, the volcanic edifice bulges and grows in reaction to the build-up of lava and gas inside the volcano.) The study included an analysis of crustal failure along the flanks of Mount Etna. Understanding the failure points of volcanoes under inflationary pressure leads to predicting volcanic eruption.

The Shuttle Radar Topography Mission, a collaboration between NASA, the National Geospatial Intelligence Agency, and the German and Italian Space Agencies, provided high-resolution topography to help scientists analyze high-resolution imaging of regional geologic structures, such as faults and volcanoes. Data from this mission also helped scientists analyze other geophysical data sets. Data released in July 2004 provided the research community with the first complete Shuttle Radar Topography Mission 90-meter-resolution database. The mission was 99.9 percent successful in providing the first uniform-accuracy topographic maps of land masses within 60 degrees of the equator with a vertical accuracy of better than 10 meters (approximately 33 feet). This data helps scientists understand the physics of earthquakes, volcanoes, and landslides within the North American plate.

NASA also began developing an airborne capability that will equip an uncrewed airborne vehicle with a synthetic aperture radar that can detect geophysical changes related to volcanic eruptions.

Outcome 1.1.14: Enable estimation of earthquake likelihood in North American plate boundaries with > 50% confidence by 2014.

This year, NASA corrected the Rundle-Tiampo statistical prediction model developed in 2002 by Kristy Tiampo of the University of West Ontario, Canada, and John Rundle of the University of California. The Rundle-Tiampo model is used to pinpoint earthquake locations in southern California for 2000-2010. NASA researchers used their improved model including detailed interferometric synthetic aperture radar measurements, to re-analyze data previously analyzed by Rundle's model and expanded the analysis to all of California. The Rundle-Tiampo forecast model, using data from NASA's Interferometric Synthetic Aperture Radar instrument, and results from NASA-Jet Propulsion Laboratory's QuakeSim project, made unprecedented forecasts of the locations for 15 of the last 16 tremors, with magnitudes greater than 5.0 on the Richter scale, since January 2000, and has successfully pinpointed the location of nearly every major tremor in the Southern California region for the last four years.

Performance Measures for Objective 1.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 1.1.1	Enable prediction of polar and global stratospheric ozone recovery (amount and timing) to within 25% by 2014.	green		Outcomes originated in FY 2004		
APG 4ESS7	Atmospheric Composition—Integrate high latitude satellite, suborbital, and ground based observations, coupled with laboratory studies and model calculations to assess the potential for future ozone depletion in the arctic, and characterize the properties and distributions of various types of clouds and aerosols as they relate to the extinction of solar radiation in the atmosphere. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.1, 1.1.2, and 1.1.3.)	green		3Y22 green 3Y4 yellow	2Y22 green 2Y4 yellow	none none
Outcome 1.1.2	Predict the global distribution of tropospheric ozone and the background concentration in continental near-surface air to within 25% by 2014.	green		Outcomes originated in FY 2004		
APG 4ESS7	Atmospheric Composition—Integrate high latitude satellite, suborbital, and ground based observations, coupled with laboratory studies and model calculations to assess the potential for future ozone depletion in the arctic, and characterize the properties and distributions of various types of clouds and aerosols as they relate to the extinction of solar radiation in the atmosphere. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.1, 1.1.2, and 1.1.3.)	green		none	none	none
Outcome 1.1.3	Enable extension of air quality forecasts for ozone and aerosols from 24 to 72 hours by 2010.	green		Outcomes originated in FY 2004		
APG 4ESS7	Atmospheric Composition—Integrate high latitude satellite, suborbital, and ground based observations, coupled with laboratory studies and model calculations to assess the potential for future ozone depletion in the arctic, and characterize the properties and distributions of various types of clouds and aerosols as they relate to the extinction of solar radiation in the atmosphere. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.1, 1.1.2, and 1.1.3.)	green		none	none	none
Outcome 1.1.4	Use satellite data to help enable decreased hurricane landfall uncertainty from +/- 400 km to +/- 100 km in the three-day forecasts by 2010.	green		Outcomes originated in FY 2004		
APG 4ESS8	Weather—Improve predictive capabilities of regional models using satellite-derived localized temperature and moisture profiles and ensemble modeling. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.4 and 1.1.5.)	green		none	none	none
Outcome 1.1.5	Use satellite data to help extend more accurate regional weather forecasting from 3 days to 5 days by 2010.	green		Outcomes originated in FY 2004		
APG 4ESS8	Weather—Improve predictive capabilities of regional models using satellite-derived localized temperature and moisture profiles and ensemble modeling. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.4 and 1.1.5.)	green		3Y19 green	2Y19 green	none
Outcome 1.1.6	Develop projections of future atmospheric concentrations of carbon dioxide and methane for 10-100 years into the future with improvements in confidence of >50% by 2014.	green		Outcomes originated in FY 2004		
APG 4ESS9	Carbon Cycles, Ecosystems, and Biogeochemistry—Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.6, 1.1.7, and 1.1.8.)	green		3Y23 green	none	none
Outcome 1.1.7	By 2014, develop in partnership with other agencies, credible ecological forecasts that project the sensitivities of terrestrial and aquatic ecosystems to global environmental changes for resource management and policy-related decision-making.	green		Outcomes originated in FY 2004		
APG 4ESS9	Carbon Cycles, Ecosystems, and Biogeochemistry—Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.6, 1.1.7, and 1.1.8.)	green		3Y3 green	2Y3 green	none

Performance Measures for Objective 1.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 1.1.8	Report changes in global land cover, productivity, and carbon inventories with accuracies sufficient for use in the food industry, in evaluating resource management activities, and in verifying inventories of carbon emissions and storage.	green		Outcomes originated in FY 2004		
APG 4ESS9	Carbon Cycles, Ecosystems, and Biogeochemistry—Reduce land cover errors in ecosystem and carbon cycle models, and quantify global terrestrial and marine primary productivity and its interannual variability. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.6, 1.1.7, and 1.1.8.)	green		3Y17 green 3Y8 green	2Y17 green 2Y8 green	none none
Outcome 1.1.9	Enable development of seasonal precipitation forecasts with >75% accuracy by 2014.	green		Outcomes originated in FY 2004		
APG 4ESS10	Water and Energy Cycle—Enhance land surface modeling efforts, which will lead to improved estimates of soil moisture and run-off. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.9 and 1.1.10.)	green		3Y1 green	2Y1 yellow	1Y5 green
Outcome 1.1.10	Improve estimates of the global water and energy cycles by 2012 to enable balancing of the global and regional water and energy budgets to within 10%.	green		Outcomes originated in FY 2004		
APG 4ESS10	Water and Energy Cycle—Enhance land surface modeling efforts, which will lead to improved estimates of soil moisture and run-off. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.9 and 1.1.10.)	green		none	none	none
Outcome 1.1.11	Reduce uncertainty in global sea level change projections by 50% by the year 2014, and include regional estimates of deviation from global mean.	green		Outcomes originated in FY 2004		
APG 4ESS11	Climate, Variability and Change—Assimilate satellite and in situ observations into a variety of ocean, atmosphere, and ice models for purposes of state estimation; provide experimental predictions on a variety of climatological timescales; and determine the plausibility of these predictions using validation strategies. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.11 and 1.1.12.)	green		3Y18 green 3Y5 green 3Y14 green	2Y18 green 2Y5 green 2Y14 green	none none none
Outcome 1.1.12	Enable 10-year or longer climate forecasts by the year 2014 with a national climate modeling framework capable of supporting policy decision-making at regional levels.	green		Outcomes originated in FY 2004		
APG 4ESS11	Climate, Variability and Change—Assimilate satellite and in situ observations into a variety of ocean, atmosphere, and ice models for purposes of state estimation; provide experimental predictions on a variety of climatological timescales; and determine the plausibility of these predictions using validation strategies. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.11 and 1.1.12.)	green		3Y10 green 3Y21 green	2Y10 green 2Y21 green	none none
Outcome 1.1.13	Enable 30-day volcanic eruption forecasts with >50% confidence by 2014.	green		Outcomes originated in FY 2004		
APG 4ESS12	Earth Surface and Interior Structure—Advance understanding of surface change through improved geodetic reference frame, estimates of mass flux from satellite observations of Earth's gravitational and magnetic fields, and airborne and spaceborne observations of surface height and deformation. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.13 and 1.1.14.)	green		none	none	none
Outcome 1.1.14	Enable estimation of earthquake likelihood in North American plate boundaries with >50% confidence by 2014.	green		Outcomes originated in FY 2004		
APG 4ESS12	Earth Surface and Interior Structure—Advance understanding of surface change through improved geodetic reference frame, estimates of mass flux from satellite observations of Earth's gravitational and magnetic fields, and airborne and spaceborne observations of surface height and deformation. Progress toward achieving outcomes will be validated by external review. (This APG applies to Outcomes 1.1.13 and 1.1.14.)	green		3Y6 green	2Y6 green	none

Goal 1 Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.

OBJECTIVE 1.2

Expand and accelerate the realization of economic and societal benefits from Earth science, information, and technology.

WHY PURSUE OBJECTIVE 1.2?

Naturally occurring and human-induced changes in Earth's system have profound consequences for the Nation and the world. NASA's Earth observing capabilities and scientific research, coupled with those from its partners, are helping society manage risks and take advantage of opportunities resulting from Earth system changes. Through improved predictions of weather, climate, and natural hazards, NASA Earth science research helps the United States and the world make sound, scientifically based decisions in areas such as agriculture, homeland security, ecology, water management, public health, and aviation safety.

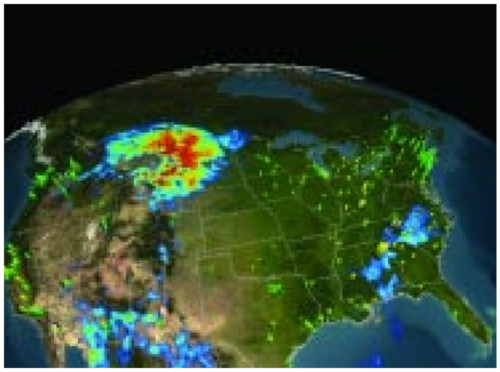


Figure 67: Air quality data from the Environmental Protection Agency, shown as three-dimensional spikes on this map of North America, is expanded and enhanced by data from the Moderate Resolution Imaging Spectroradiometer on the Terra and Aqua satellites, shown as the color overlay. In this image, green indicates healthy air while red indicates unhealthy air.

By working with Federal agency partners, NASA improves essential public services like tracking hurricanes, assessing crop health and productivity, evaluating forest fire risks, ensuring aviation safety, improving energy forecasts, and determining the potential for the climate-driven spread of infectious disease. NASA's Earth-observing systems and Earth science models advance researchers' ability to understand and protect Earth, its resources, and its diverse and precious life.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 1.2.1: By 2012, benchmark the assimilation of observations (geophysical parameters, climate data records) provided from 20 of the 80 remote sensing systems deployed on the flotilla of 18-22 NASA Earth observation research satellites.

This year, NASA and the Environmental Protection Agency's Office of Air Quality Planning and Standards partnered to create a prototype Web-based pollution forecast tool to improve the Environmental Protection Agency's air quality index forecasts. The tool uses data from NASA's Moderate Resolution Imaging Spectroradiometer aboard the Terra and Aqua satellites to forecast air quality and pollution. The Environmental Protection Agency recently integrated the tool into its AIRNow Forecaster Training Workshops, which reach over 200 air quality forecasting professionals.

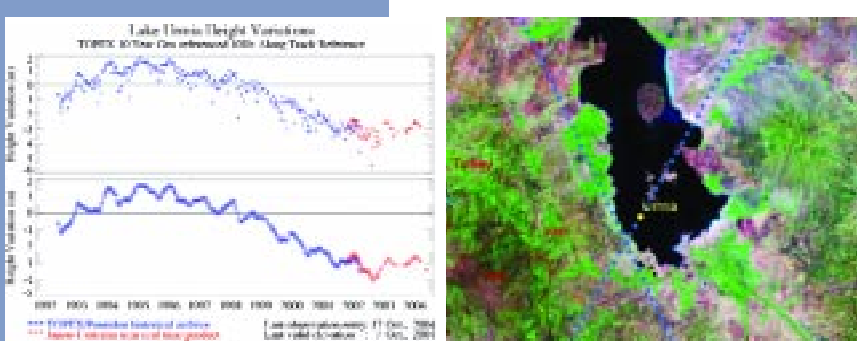


Figure 68: The chart at left shows the relative lake height variations for Lake Urmia, Iran, computed from TOPEX/POSEIDON and Jason-1 altimetry data. It shows that water height has declined steadily since the mid-1990s. The map on the right, taken by Landsat-5, shows the path (marked with blue dots) taken by the Jason-1 spacecraft. Information on this and other lakes and reservoirs around the worlld are available on the U.S. Department of Agriculture Foreign Agricultural Service's Crop Explorer Web site, at www.pecad.fas.usda.gov/cropexplorer/global_reservoir/.

Using radar altimetry data from NASA's TOPEX/Poseidon and Jason-1 satellites, researchers from NASA, the U.S. Department of Agriculture's Foreign Agricultural Service, and the University of Maryland estimated reservoir height and water volume in approximately 100 lakes and reservoirs around the world's major agricultural regions to locate regional droughts and improve crop production estimates for irrigated regions located downstream. The Foreign Agriculture Service also uses NASA-produced water availability information to make decisions about global agricultural estimates. In a related study, students in NASA's Digital Earth Virtual Environment and Learning Outreach Project program applied NASA research results in testing several new water and energy decision-support tools.

Outcome 1.2.2: By 2012, benchmark the assimilation of 5 specific types of predictions resulting from Earth Science Model Framework (ESMF) of 22 NASA Earth system science models.

Supported by Federal, private sector, and academic partnerships, NASA continues to make strides toward this Outcome. This year, NASA catalogued the Earth System Model Data Framework climate and weather prediction models that use data and observations from NASA research satellites. The Agency also evaluated data from its Atmospheric Infrared Sounder temperature and moisture profiles for use in disaster management and aviation applications, including National Oceanic and Atmospheric Administration's Statistical Hurricane Prediction Scheme model. In addition, with the help of the U.S. Geological Survey and the U.S. Department of Agriculture, NASA evaluated results from its Carnegie–Ames–Stanford Approach (CASA) model (developed by scientists from NASA's Ames Research Center, the Carnegie Institute, and Stanford University) and CASA–Carbon Query and Evaluation Support Tools (CQUEST) for use in the Invasive Species Forecasting System that provides decision support for ecosystem and carbon management applications. Using vegetation data from NASA's Moderate Resolution Imaging Spectroradiometer aboard the Terra and Aqua satellites, the CASA model predicts photosynthesis rates, the amount of vegetation and living organisms within a unit area, and "litterfall," which is organic matter from the biosphere that moves to litter layer in soil. CQUEST allows Web users to display, manipulate, and save ecosystem model estimates of carbon sinks (a reservoir that absorbs and stores carbon dioxide from the atmosphere) and carbon dioxide fluctuations in agricultural and forest ecosystems for locations anywhere in the United States.

Outcome 1.2.3: By 2012, benchmark the assimilation of observations and predictions resulting from NASA Earth Science research in 8-10 decision support systems serving national priorities and the missions of Federal agencies.

NASA partnered with a number of Federal agencies to produce decision support systems using NASA Earth science research. The table below highlights some of the ongoing partnerships and decision support systems currently in development.

Partner Agency	Activity
U.S. Department of Agriculture	Global crop production assessment NASA Carnegie–Ames–Stanford Approach (CASA) model and CASA–Carbon Query and Evaluation Support Tool (CQUEST)
Environmental Protection Agency	AirNow and Air Quality Forecasting decision support tools
Federal Aviation Administration	Advanced Weather Interactive Processing System
U.S. Geological Survey	Invasive Species Forecasting System
Federal Emergency Management Agency	HAZUS–US tool, a National Flood Loss Estimation Model
U.S. Agency for International Development (AID) and Central American Commission for Environment and Development	SERVIR tool, a regional visualization and monitoring system that will assist the seven nations of Central America in developing a Mesoamerican Biological Corridor extending from southern Mexico to the Colombian border
Department of Homeland Security	International Materials Assessment and Application Centre
Centers for Disease Control	California Environmental Public Health Tracking Network
U.S. Department of the Interior	RiverWare and Agricultural Water Resources Decision Support tools
National Oceanic and Atmospheric Administration	Coral Reef Early Warning System tool

Performance Measures for Objective 1.2		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 1.2.1	By 2012, benchmark the assimilation of observations (geophysical parameters, climate data records) provided from 20 of the 80 remote sensing systems deployed on the flotilla of 18–22 NASA Earth observation research satellites.	green		Outcomes originated in FY 2004		
Outcome 1.2.2	By 2012, benchmark the assimilation of 5 specific types of predictions resulting from Earth Science Model Framework (ESMF) of 22 NASA Earth system science models.	green		Outcomes originated in FY 2004		
Outcome 1.2.3	By 2012, benchmark the assimilation of observations and predictions resulting from NASA Earth Science research in 8–10 decision support systems serving national priorities and the missions of federal agencies.	green		Outcomes originated in FY 2004		
APG 4ESA1	National applications—Benchmark measurable enhancements to at least 2 national decision support systems using NASA results, including the use of optical depth derived from MODIS data into the Air Quality Index provided by EPA and the use of ocean height derived from Topex and Jason missions into reservoir monitoring tools with USDA. (This APG applies to Outcomes 1.2.1 and 1.2.3.)	green		3Y24 green	2Y23 green	1Y14 green
APG 4ESA2	Cross Cutting Solutions—Expand DEVELOP (Digital Earth Virtual Environment and Learning Outreach Project) workforce development program to 2-4 additional states and benchmark the use of NASA research results for water and energy decision support tools. (This APG applies to Outcomes 1.2.1, 1.2.2, and 1.2.3.)	green		none	none	none
APG 4ESA3	Cross Cutting Solutions—Competitively select at least 5 solutions projects for the Research, Education, Applications Solutions Network (REASoN) program to serve national applications through projects that support agriculture, public health and water quality decision support tools. (This APG applies to Outcomes 1.2.1, 1.2.2, and 1.2.3.)	green		none	none	none
APG 4ESA4	Cross Cut Solutions—Verify and validate at least two commercial remote sensing sources/products for Earth science research including DigitalGlobe Quicksat and OrbImage Overview-3 high resolutions optical imagery. (This APG also applies to Outcome 1.2.1.)	green		none	none	none

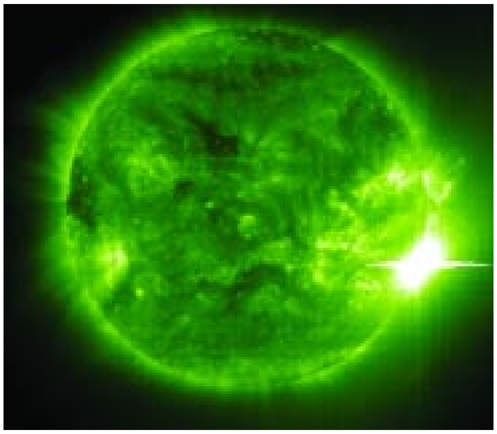
Goal 1 Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.

OBJECTIVE 1.3

Understand the origins and societal impacts of variability in the Sun–Earth connection.

WHY PURSUE OBJECTIVE 1.3?

Life on Earth prospers in a biosphere sustained by energy from the Sun. Changes in the Sun can cause long- and short-term changes on Earth, affecting global climate, disrupting communication and navigation systems, and posing a radiation danger for humans in space.



Credit: NASA/ESA/EIT Consortium

Figure 69: A giant sunspot region lashed out with a huge solar flare (visible on the right side of the Sun) followed by a large coronal mass ejection on November 4, 2003, captured in this extreme ultraviolet image taken by the Solar and Heliospheric Observatory. The energetic particle radiation caused substantial radio interference on Earth.

NASA seeks to develop the scientific understanding necessary to predict and mitigate the effects of solar changes. With help from its partners, NASA forecasts solar activity, measures the radiation that bombards Earth, and studies Earth's atmosphere and magnetic field that shields life from this radiation. NASA is probing the links between the Sun's variable layers and Earth's protective layers. With NASA's help, researchers are beginning to understand the physics of space weather, the diverse array of dynamic and interconnected phenomena that affect both life and society. NASA also is characterizing the radiation environment to improve spacecraft designs and to protect astronauts as they venture beyond Earth.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 1.3.1, 1.3.2, and 1.3.3 and determined that NASA successfully demonstrated progress in all three Outcomes during FY 2004.

Outcome 1.3.1: Develop the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect the Earth.

This year, The Advanced Composition Explorer spacecraft measured the effects of a coronal mass ejection that produced solar wind speeds in excess of 1100 miles-per-second, the fastest ever directly observed. (A coronal mass ejection occurs when the Sun ejects huge bubbles of gas over the course of several hours, often disrupting the flow of the solar wind and producing disturbances on Earth and throughout the solar system.) Shock waves from the coronal mass ejection produced and heated the fast winds to temperatures greater than 10 million degrees, the hottest ever recorded in the solar wind. Using observations from the Solar and Heliospheric Observatory, researchers confirmed the theory that coronal mass ejections begin as slow eruptions in which the magnetic fields tethering the material to the Sun become stretched and break, allowing the coronal mass ejection to rapidly accelerate and heat. Fast coronal mass ejections cause some of the most violent space weather, including energetic particles hazardous to astronauts, so studying such events helps NASA predict and prepare for extreme space weather that could pose a threat to astronauts in space or technology on Earth.

Supported by the Living with a Star Targeted Research and Technology Program, researchers developed a solar cycle prediction model based on new discoveries about the Sun's magnetic field. Solar cycles usually last about 11 years. The model explains the unusual behavior observed in the last solar cycle and predicts a 6 to 12 month delay for the onset of the next cycle. In addition, NASA scientists tested techniques to forecast interplanetary space weather during a fortuitous alignment of planets while the Cassini spacecraft flew by Jupiter. The test traced solar wind surge from Earth to Jupiter, and the close alignment enabled researchers to predict conditions at Jupiter with impressive accuracy (1 day advance notice for the arrival time of a surge with 5-10 day duration).

Outcome 1.3.2: Specify and enable prediction of changes to the Earth's radiation environment, ionosphere, and upper atmosphere.

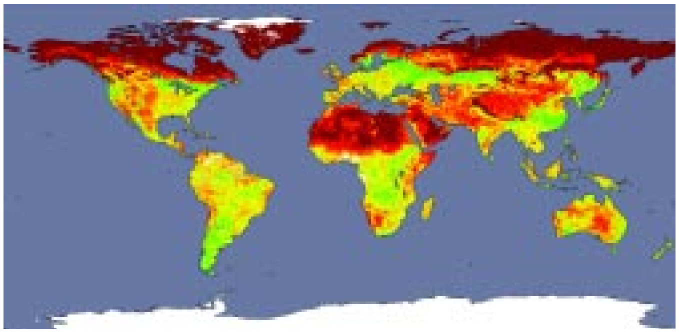
This year, the Solar, Anomalous, and Magnetospheric Particle Explorer completed a 12-year survey of the radiation particle environment of low Earth orbit. Scientists will use the resulting data to help them specify galactic rays, anomalous cosmic rays, and other solar energetic particle events in which high-energy particles are ejected from the Sun. Other Studies of solar energetic particle events by the Solar, Anomalous, and Magnetospheric Particle Explorer and the Advanced Composition Explorer revealed that partially ionized heavier particles, such as iron, escape from solar events more easily. These results and measurements demonstrate the need to improve continuously the engineering models used for predicting the range of radiation effects that can be expected over the lifetime of a space mission. This research also will help scientists define future tests leading to improved prediction of hazardous space radiation.

The Thermosphere, Ionosphere, Mesosphere, Energetics, and Dynamics satellite, designed to study the effects of the Sun on Earth's atmosphere, captured for the first time satellite-based temperature measurements covering both day and night from 68 to 74 miles above Earth. Using data from the satellite, scientists developed a global map of ionospheric plasma depletions and electron density profiles that will be incorporated into the International Reference Ionosphere model, an international project sponsored by the Committee on Space Research and the International Union of Radio Science to characterize the ionosphere, including electron density, electron temperature, ion temperature, and ion composition.

Outcome 1.3.3: Understand the role of solar variability in driving space climate and global change in Earth's atmosphere.

NASA's fleet of science satellites traced the flow of energy from the Sun, through interplanetary space, to its dissipation in Earth's atmosphere during massive increases in solar flares and coronal mass ejections. Large, dark sunspots caused remarkable decreases in solar radiative output, better known as sunlight, whereas remendous solar flares caused increases. The project captured immediate and delayed response of the Sun–Earth system on a global scale. From this, scientists are gaining new perspectives on Sun–Earth system plasma, dynamics, and chemical processes.

By monitoring the glow of light reflected from Earth onto the moon's dark side, the Living with a Star Targeted Research Technology Program showed that the Earth's average albedo (reflectivity) varies considerably over time. During the 1980s and 1990s, the Earth bounced less sunlight out to space, but the trend reversed during the past three years. Although the reasons for these trends are not fully understood, scientists believe that the decrease in reflected sunlight was related to an increase in mean global surface temperatures, and the recent increases to changes in cloud properties. The research offers evidence that Earth's average albedo varies considerably from year to year, and from decade to decade. Scientists must conduct more research into solar variability and climate change before they can confidently model future albedo changes.



Credit: C. Schaat, Boston University

Figure 70: The MODIS instrument, flying aboard NASA's Terra and Aqua satellites, measures how much solar radiation is reflected by the Earth's surface over the entire planet. Areas colored red show the most reflective regions; yellows and greens are intermediate; and blues and violets show relatively dark surfaces. White indicates no data was available, and no albedo data are provided over the oceans. This image was produced using data composited from April 7–22, 2002.

NASA's Scientific Ballooning Program launched the Solar Bolometric Imager and made the first precision broadband light images of the Sun. These spatially resolved absolute measurements of total solar irradiance will allow the sources of radiance to be understood and quantified separately clarifying the Sun's role in global climate change.

NASA's Theory Program simulations used solar irradiance data to model the solar rotational behavior of Earth's upper atmosphere and successfully predict and measure its effects on satellites.

Performance Measures for Objective 1.3		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 1.3.1	Develop the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect Earth.	green		Outcomes originated in FY 2004		
APG 4SEC8	Successfully demonstrate progress in developing the capability to predict solar activity and the evolution of solar disturbances as they propagate in the heliosphere and affect Earth. Progress towards achieving outcomes will be validated by external review.	green		3S7 green	2S7 green	none
Outcome 1.3.2	Specify and enable prediction of changes to Earth's radiation environment, ionosphere, and upper atmosphere.	green		Outcomes originated in FY 2004		
APG 4SEC9	Successfully demonstrate progress in specifying and enabling prediction of changes to Earth's radiation environment, ionosphere, and upper atmosphere. Progress towards achieving outcomes will be validated by external review.	green		3S8 green	2S8 green	1S11 green
Outcome 1.3.3	Understand the role of solar variability in driving space climate and global change in Earth's atmosphere.	blue		Outcomes originated in FY 2004		
APG 4SEC10	Successfully demonstrate progress in understanding the role of solar variability in driving space climate and global change in Earth's atmosphere. Progress towards achieving outcomes will be validated by external review.	blue		none	none	none

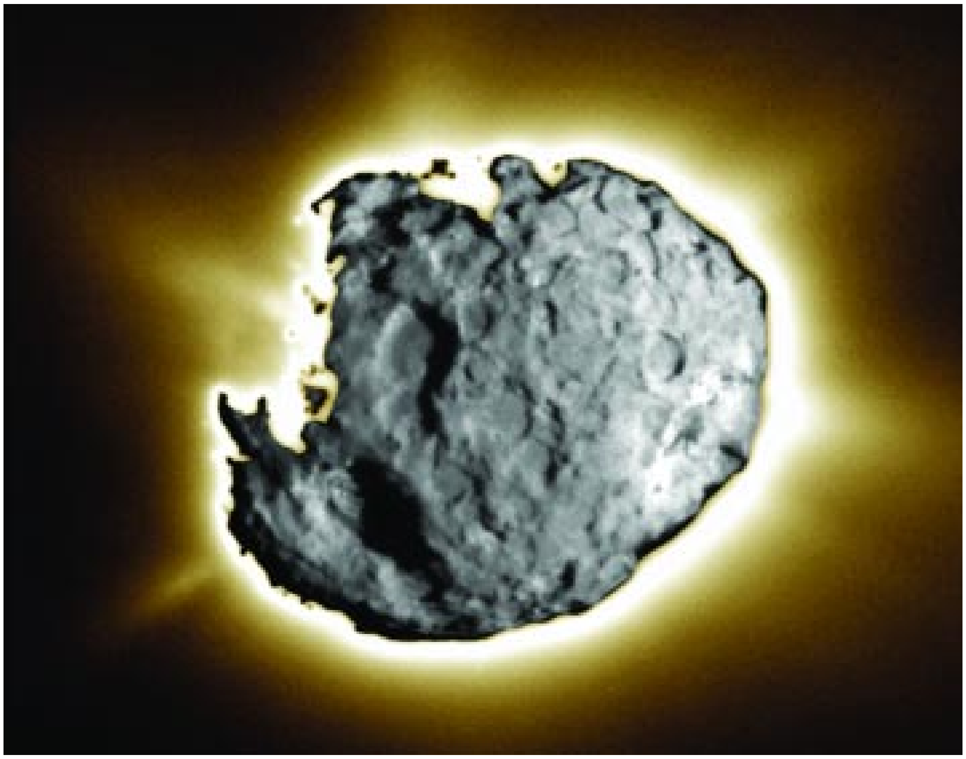
Goal 1 Understand the Earth system and apply Earth system science to improve prediction of climate, weather, and natural hazards.

OBJECTIVE 1.4

Catalog and understand potential impact hazards to Earth from space.

WHY PURSUE OBJECTIVE 1.4?

The solar system is filled with rocky and icy debris that orbits the Sun—"leftovers" created when the solar system was young. The vast majority of this debris harmlessly passes by Earth, but occasionally some debris collides with this planet, creating a cosmic impact. The effects of cosmic impacts on Earth were realized in the 1980s when scientists found indications that the impact of an asteroid, at least ten kilometers in diameter, had caused the climatic changes that led to the mass extinction of the dinosaurs. Scientists estimate that impacts by asteroids as small as one kilometer (more than six miles) in diameter could cause major global climate changes, even global devastation. An impact by a body as small as 100 meters (about 328 feet across) could cause major damage to an entire metropolitan area.



Credit: NASA JPL/Caltech

Figure 71: This composite image, taken by the Stardust spacecraft during its January 2, 2004, flyby of Comet Wild 2, shows a rocky, cratered surface surrounded by glowing jets of dust and gas that leave a trail millions of kilometers long.

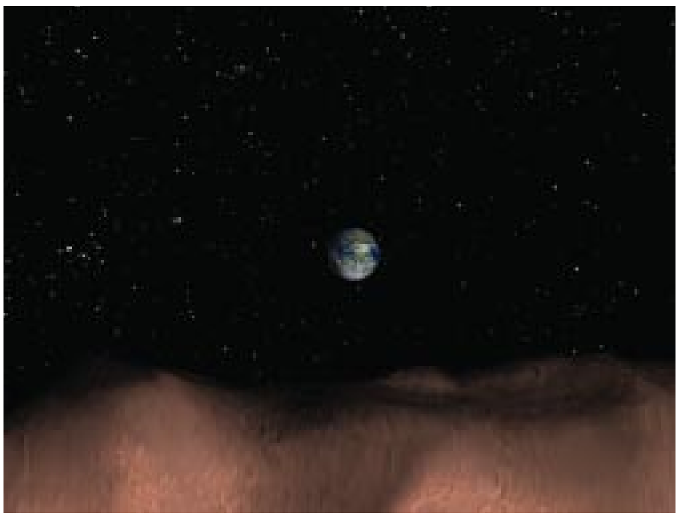
NASA is working toward an FY 2008 goal of identifying and inventorying at least 90 percent of all asteroids and comets larger than one kilometer in diameter that could come near Earth. By determining their orbits with sufficient accuracy, researchers could then predict whether any of them will pose a threat to Earth.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 1.4.1 and 1.4.2 and determined that NASA successfully demonstrated progress in both Outcomes during FY 2004.

Outcome 1.4.1: By 2008, inventory at least 90 percent of asteroids and comets larger than 1 km in diameter that could come near Earth.

From May 2003 to May 2004, programs sponsored by NASA's Near Earth Object Observation Program discovered 68 new near-Earth asteroids with diameters estimated to be larger than 1 kilometer (approximately 0.6 miles) in diameter (out of a total of 481 near Earth asteroids of all sizes). Of these 68, NASA scientists found that 15 posed a potential collision threat to Earth sometime in the future—but not for at least 200 years. Scientists estimate that the total population of near-Earth asteroids with diameters larger than 1 kilometer is about 1100, and to date, they have identified 716.



Credit: NASA JPL/Caltech

Figure 72:Toutatis, a potato-shaped asteroid about 4.6 kilometers (3 miles) long, passed within 1,550,000 kilometers (963,000 miles) of Earth's center on September 29, 2004—approximately four times the distance of Earth to the Moon. This is the closest Earth approach this century for a known asteroid of this size. This artist's image depicts the asteroid's view of Earth during another close pass in November 1996.

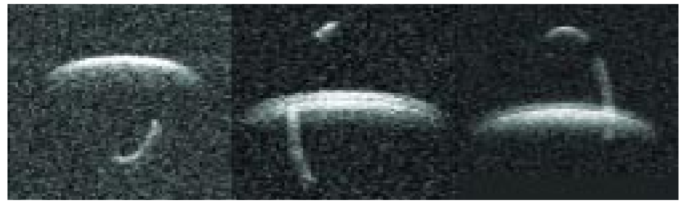


Figure 73: After eluding astronomers for decades, Dr. Jean-Luc Margot caught a glimpse of near-Earth asteroid 1999 KW4, also known as Hermes. His team discovered that the asteroid, shown here in a series of images taken by NASA's Goldstone radar system, is actually two objects: a component orbiting around a slightly larger mass.

Outcome 1.4.2: Determine the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth.

The Goldstone and Arecibo Deep Space radar systems imaged the asteroid Hermes, a near-Earth, potentially hazardous asteroid that has not been seen since its discovery in 1937. The radar imaging revealed that Hermes actually consists of two objects held close to each other by their mutual gravitational attraction. Hermes, which has the most chaotic orbit of all near-Earth objects, can get as close to Earth as 608,000 kilometers (about 378,000 miles).

Scientists believe that comets, some of the oldest bodies in the solar system, are a major source of near-Earth asteroids. In January 2004, NASA's Stardust spacecraft rendezvoused with Wild 2, a comet passing relatively close to Earth, and returned images revealing that the nucleus of the comet is heavily cratered. This shows that the nucleus of Wild 2 consists of cohesive materials like ice, contradicting earlier beliefs that all comet nuclei are loosely bound aggregates of snow and dirt. The samples and images from Stardust will provide valuable insights into the building blocks of the early solar system and the characteristics of the small solar system bodies (e.g., asteroids) that were formed during this period.

Performance Measures for Objective 1.4		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 1.4.1	By 2008, inventory at least 90 percent of asteroids and comets larger than 1 km in diameter that could come near Earth.	green		Outcomes originated in FY 2004		
APG 4SSE10	Successfully demonstrate progress in determining the inventory and dynamics of bodies that may pose an impact hazard to Earth. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 1.4.2	Determine the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth.	green		Outcomes originated in FY 2004		
APG 4SSE11	Successfully demonstrate progress in determining the physical characteristics of comets and asteroids relevant to any threat they may pose to Earth. Progress towards achieving outcomes will be validated by external review.	green		3S8 green	2S8 blue	none

Goal 2
Enable a safer, more secure, efficient, and environmentally friendly air transportation system.

OBJECTIVE 2.1

Decrease the aircraft fatal accident rate, reduce the vulnerability of the air transportation system to hostile threats, and mitigate the consequences of accidents and hostile acts.

WHY PURSUE OBJECTIVE 2.1?

Safety is one of NASA's core values. The Agency is committed to protecting the safety and health of the public, NASA's partners, NASA's people, and the assets that the public entrusts to the Agency. As part of this commitment, NASA is developing new and improved technologies that will ensure air transportation safety. Through advances in modeling and technology, NASA complements and extends improvements to operations, training, and technology made by the Federal Aviation Administration, the Department of Homeland Security, the Transportation Security Administration, and private industry.

Figure 74: NASA's Rogue Evaluation and Coordination Tool provides real-time information about aircraft that deviate from their expected flight path, allowing air traffic controllers to identify collision risks or potential terrorist threats.

NASA is creating new models for aviation safety management, including real-time identification and mitigation of risk at all levels, while continuing proactive work with other government agencies and industry to address issues impeding the improvement of aviation safety. The Agency's highest priority in this area is to research the most common causes of accidents. Other key areas of NASA research and technological development are flight during hazardous weather, controlled flight into terrain, air traffic management, human-error-induced accidents and incidents, and mechanical or software malfunctions.

NASA also is examining security concepts and technologies that could help stop terrorist acts. For example, NASA is using its unique resources to help prevent aircraft sabotage (the disruption of the command, navigation, and surveillance infrastructure) and to protect the transportation system from electronic viruses.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 2.1.1: By 2005, research, develop, and transfer technologies that will enable the reduction of the aviation fatal accident rate by 50% from the FY 1991–1996 average.

NASA completed a final integrated program assessment in September 2004. The assessment included: examining the projected impact of integrated research projects in NASA's Safety Program on aircraft accident rates; assessing the cost and benefits of proposed safety products; and reviewing changes in technical and implementation risks associated with aviation safety product development.

NASA also designed and manufactured full-scale engine components using alternative composite materials that will be tested for improved material integrity. And, the Agency completed simulation and flight-test evaluations of low-cost, forward-fit and retrofit Synthetic Vision technologies for general aviation aircraft in June 2004. During all of these tests and evaluations, engineers assessed the technical and operational performance of improved pilot situational awareness with regard to terrain portrayal, loss of control prevention, and display symbols. The results demonstrated the efficacy of Synthetic Vision's displays to eliminate a primary cause of general aviation accidents—controlled flight into terrain because the pilot could not see terrain changes—and greatly improve pilot situational awareness.

Outcome 2.1.2: By 2009, research, develop, and transfer technologies that will reduce the vulnerability exposure of the aircraft, and reduce the vulnerabilities of other components in the air transportation system.

NASA began implementing two new aviation security projects: System Vulnerability Detection and Aviation and Systems Vulnerability Mitigation. In June 2004, NASA completed a preliminary demonstration of the Rogue Evaluation And Coordination Tool, a security decision support program. Researchers evaluated the tool using a live traffic feed over eight hours for both the Fort Worth, Texas and Washington, D.C., air traffic control centers. The tool successfully detected aircraft that were deviating from their expected flight paths using four different methods. It also predicted incursions into restricted airspace, with countdown timers to entry into that airspace. These capabilities will enhance public safety by mitigating the potential for catastrophic harm that might otherwise result from a rogue aircraft.

Performance Measures for Objective 2.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 2.1.1	By 2005, research, develop, and transfer technologies that will enable the reduction of the aviation fatal accident rate by 50% from the FY 1991–1996 average.	green		Outcomes originated in FY 2004		
APG 4AT4	Utilizing results of component testing, simulations, and analyses, complete an integrated program assessment of the suite of aviation safety technologies to determine their synergistic effect on reducing the fatal accident rate.	green		3R1 yellow	2R1 green	none
APG 4AT5	Propulsion system malfunctions are cited in 25% of fatal accidents, with disk and/or fan blade component failures being attributed to about 15% of these malfunctions. In FY 2004 NASA will develop prototype disks and engine containment materials with inherent failure resistant characteristics that will be ready for full scale testing in FY 2005.	green		none	none	none
APG 4AT6	Controlled Flight into Terrain (CFIT) accounts for 30% of General Aviation fatal accidents. During FY 2004, NASA will complete the flight evaluation of a synthetic vision system that improves pilot situational awareness by providing a display of "out-the-window" information that is not effected by adverse metrological conditions. This system when fully implemented has the potential to eliminate 90% of CFIT accidents.	green		none	none	none
Outcome 2.1.2	By 2009, research, develop and transfer technologies that will reduce the vulnerability exposure of the aircraft, and reduce the vulnerabilities of other components in the air transportation system.	green		Outcomes originated in FY 2004		
APG 4AT7	Complete a preliminary demonstration, in a realistic operational environment, of an automated system to provide real-time identification of flight path deviations and a means to alert authorities in a prompt and consistent manner.	green		none	none	none

Goal 2 Enable a safer, more secure, efficient, and environmentally friendly air transportation system.

OBJECTIVE 2.2

Protect local and global environmental quality by reducing aircraft noise and emissions.

WHY PURSUE OBJECTIVE 2.2?

The air transportation system is integral to economic growth, national security, and enhanced quality of life. Therefore, NASA is developing technologies that reduce the negative environmental impacts of aviation operations. NASA seeks to reduce aircraft carbon dioxide greenhouse emissions by creating clean-burning engines and new energy sources like solar-electric fuel cells. The Agency's research into lighter-weight vehicles and components will reduce fuel consumption. NASA also is pursuing innovative vehicle concepts, such as blended-wing bodies and vaneless, counter-rotating turbomachinery that show potential for reducing the emissions that create smog and global warming.

Figure 75: A fan designed to reduce aircraft noise is tested in a NASA laboratory.

In addition, NASA is developing new tools that will enable researchers to identify and model aircraft noise sources and find ways to reduce this noise to acceptable, community-friendly levels. As part of this effort, NASA is exploring low-noise propulsion systems, advanced vehicle concepts, advanced materials, and innovative noise-shielding techniques that keep objectionable noise within airport boundaries. And, NASA partnerships with the aerospace industry and other government agencies are identifying the key technologies needed to increase engine and airframe efficiency and to speed the transfer of environmentally friendly technologies to the marketplace—and to local airports.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 2.2.1: By 2007, develop, demonstrate and transfer technologies that enable a reduction by half, in community noise due to aircraft, based on the 1997 state of the art.
In FY 2004, NASA validated an initial set of noise-reduction concepts for airframes and engines by testing components in wind tunnel and engine rig experiments. The concept tests verified the potential for significant noise reduction with minimal loss of performance. In addition, researchers performed acoustic (sound) and aerodynamic performance tests on a new swept and tapered wing concept in aircraft approach flow conditions. Low-noise modifications to the high-lift devices on the wings reduce noise while maintaining wing performance.

NASA also successfully tested modifications to aircraft fan and nozzle designs and validated the noise reduction predicted for those concepts. The test results validate noise-reduction projections that, when combined with benefits from other noise-reduction techniques, resulted in a five-decibel reduction relative to the 2001 state of the art. The total suite of technologies, including those developed in previous programs, is projected to reduce aircraft noise sufficiently to meet NASA's ten-year goal of reducing perceived noise from aircraft by one-half (ten decibels) relative to 1997 state of the art.

Outcome 2.2.2: By 2007, develop, demonstrate and transfer technologies for reducing NOx emission by 70% from the 1996 ICAO standard, to reduce smog and lower atmospheric ozone.

Although NASA's progress slipped by one quarter, the Agency expects to achieve this Outcome on schedule. This year, NASA produced preliminary designs for full-annular combustors (which mix fuel with air for combustion) that exhibit the low nitrous-oxide emission characteristics that were demonstrated previously in combustor sector tests. These full-annular combustor designs include considerations for commercial service, and they are compatible with existing and future engine families. They also meet requirements for flight safety, component life, affordability, and maintainability at levels appropriate for product viability. NASA plans to complete the detailed design for the 2005 full-annular combustor test by December 30, 2004.

Outcome 2.2.3: By 2007, develop, demonstrate and transfer technologies for reducing the green-house gas, CO2, emissions by 25% based on the state of the art for airframe and engine component technologies in 2000.

NASA plans to complete this Outcome in FY 2005. This year, NASA designed a two-stage compressor rig with 50 percent higher stage loading than the currently flying engine compressor. NASA also modified an existing facility to collect flow measurement data using state-of-the-art instrumentation. Researchers completed fabrication of the compressor rig hardware and began the assembly and nstrumentation process. NASA will test the two-stage compressor rig to validate its improved performance by November 30, 2004.

Figure 76: NASA's new two-stage, highly-loaded compressor casing assembly should improve engine efficiency.

Performance Measures for Objective 2.2		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 2.2.1	By 2007, develop, demonstrate and transfer technologies that enable a reduction by half, in community noise due to aircraft, based on the 1997 state of the art.	green		Outcomes originated in FY 2004		
APG 4AT8	Validate initial concepts for engine and airframe source noise reduction by 5dB (re: to CY 2001 SOA).	green		3R3 green	2R3 green	1R3 yellow
Outcome 2.2.2	By 2007, develop, demonstrate and transfer technologies for reducing NOx emission by 70% from the 1996 ICAO standard, to reduce smog and lower atmospheric ozone.	green		Outcomes originated in FY 2004		
APG 4AT19	Complete detailed design of a low-emission combustor leading to a 2005 test of a full-annular combustor demonstrating a 70% reduction of nitrogen oxides.	yellow		3R2 green	2R2 green	1R2 green
Outcome 2.2.3	By 2007, develop, demonstrate and transfer technologies for reducing the green-house gas, CO2, emissions by 25% based on the state of the art for airframe and engine component technologies in 2000.	green		Outcomes originated in FY 2004		
APG 4AT9	Experimentally demonstrate a 2-stage highly loaded compressor for increasing pressure rise per stage.	yellow		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 2
Enable a safer, more secure, efficient, and environmentally friendly air transportation system.

OBJECTIVE 2.3

Enable more people and goods to travel faster and farther, with fewer delays.

WHY PURSUE OBJECTIVE 2.3?

In December 2003, the world commemorated 100 years of powered flight. Air transportation has greatly evolved over those 100 years, from fragile, propeller-driven planes to jets that allow passengers to journey across the country or across the globe with speed and ease. Since 1958, NASA technology has spurred this evolution, and the Agency continues to develop technologies for the next phase of air transportation.

Figure 77: Long queues to take off are a common problem at some airports around the country. NASA and its partners are developing technologies that will help relieve some of this congestion.

NASA is working closely with other government agencies and industry to modernize equipment, software, and procedures for significant improvements in air traffic management both in the air and on the ground. The Agency is developing and testing new vehicle concepts and technologies to reduce aircraft weight, improve aerodynamic performance, and increase speed. NASA is helping to maximize airport capacity in all types of weather, expand throughput at the Nation's small airports, effectively manage high-density traffic flows, and design aircraft that can operate on short runways. As part of this effort to improve airport flow and traffic management, NASA is developing technologies to enable high-bandwidth, highly reliable, secure networks with global connectivity, ensuring safe and secure links between aircraft and the ground. And, NASA models and simulations are helping researchers understand the human operator, improving safety and performance throughout the complex air transportation system.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 2.3.1: By 2004, develop, demonstrate and transfer technologies that enable a 35% increase in aviation system throughput in the terminal area and a 20% increase in aviation system throughput en route based on 1997 NAS capacities.

In FY 2004, NASA developed, tested, and, in some cases, transferred to the Federal Aviation Administration for deployment, advanced air transportation technologies decision support tools. These products will enable improvements in National Airspace System throughput, user flexibility, predictability, and overall system efficiency while maintaining safety. The results were so promising that the Radio Technical Commission for Aeronautics (a Federal advisory committee to the Federal Aviation Administration on policy, program, and regulatory decisions) selected NASA's Surface Management System and Multi-Center Traffic Management Advisor decision support tools to become part of the Federal Aviation Administration Free Flight Phase 2 Program, a program to create modernized computer hardware and software tools to help air traffic controllers and airlines.

Outcome 2.3.2: By 2005, develop, demonstrate and transfer key enabling capabilities for a small aircraft transportation system.

This year, NASA conducted flight experiments for Integrated Evaluation of High Volume Operations, Lower Landing Minima, and Single Pilot Performance. The results will be used to evaluate the technologies and flight scenarios for the 2005 Technology Demonstration.

Outcome 2.3.3: By 2009, develop, demonstrate, and transfer technologies that enable a further 5% increase in throughput in the terminal area and a further 10% increase in en route throughput based on 1997 NAS capacity.

NASA successfully completed two versions of the Airspace Concept Evaluation System simulation system designed to measure the effects of a new airspace concept on the National Airspace System. By modeling key features of a concept (or competing concepts), the system explores the interactions between participants and factors in the National Airspace System and decides which new concept is best. Development of the third version of the System is on schedule. The latest version features a higher fidelity terminal model, supports international flights, and has improved support for Advanced Airspace Concept modeling. In addition, NASA completed site visits to Cleveland's Air Route Traffic Control Center and Northwest Airlines' System Operations Control Center to collect field data and awarded a contract to support development of a preliminary operational concept description. Work is in progress and on schedule.

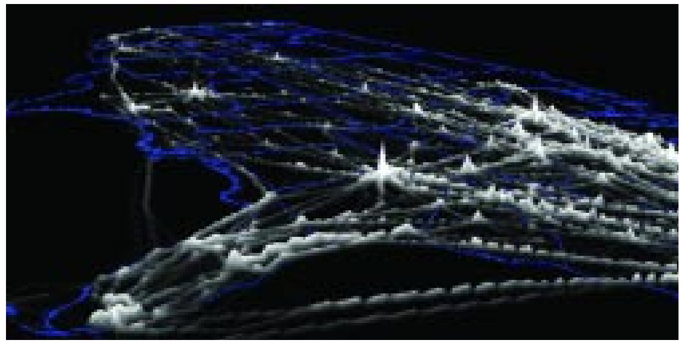


Figure 78: The Airspace Concept Evaluation System is a non-real-time modeling system for the National Airspace System. This is a JVIEW (an Air Force Research Laboratory application programmers interface) three-dimensional view of aircraft density across the United States for a 24-hour period.

Performance Measures for Objective 2.3		2004 Rating	Past Years' Performance Measures and Ratings: 2003	2002	2001
Outcome 2.3.1	By 2004, develop, demonstrate and transfer technologies that enable a 35% increase in aviation system throughput in the terminal area and a 20% increase in aviation system throughput en route based on 1997 NAS capacities.	green	Outcomes originated in FY 2004		
APG 4AT10	Complete validation and assessment of the Advanced Air Transportation Technologies products (tools/concepts) through field and laboratory demonstrations, analyses, evaluations, and assessments on a tool-by-tool basis to demonstrate an increase in terminal throughput by 35 percent and an increase in en route throughput by 20 percent.	green	3R5 green	2R5 green	none
			3R4 green	2R4 green	none
Outcome 2.3.2	By 2005, develop, demonstrate and transfer key enabling capabilities for a small aircraft transportation system.	green	Outcomes originated in FY 2004		
APG 4AT12	Flight demonstrate the ability to double the operations rate at non-towered, non-radar airports in low-visibility conditions using self-separation and flight-path guidance technologies for general aviation aircraft.	green	none	none	none
Outcome 2.3.3	By 2009, develop, demonstrate, and transfer technologies that enable a further 5% increase in throughput in the terminal area and a further 10% increase in en route throughput based on 1997 NAS capacity.	green	Outcomes originated in FY 2004		
APG 4AT11	Develop a non-real-time Virtual Airspace Simulation Technology environment that will model the National Airspace System and provide the capability to conduct trade-off analyses amongst concepts and technologies for the future air transportation system.	green	none	none	none
APG 4AT13	Based on research completed under AATT project and current work under VAMS project, provide preliminary analysis and assessment of distributed air/ground traffic management (DAG/TM) operational concept.	green	none	none	none

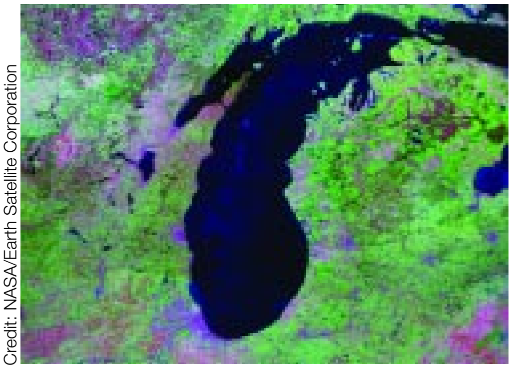
Goal 3
Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.

OBJECTIVE 3.1

Enhance the Nation's security through partnerships with DoD, the Department of Homeland Security, and other U.S. or international government agencies.

WHY PURSUE OBJECTIVE 3.1?

NASA is a partner with the Department of Defense, the Department of Homeland Security, and other Federal agencies in maintaining national and global security. NASA maintains liaisons with these agencies, establishes joint agreements, reviews research and technology plans, and employs other mechanisms to develop common research objectives and leverage the results of each agency's research.



Credit: NASA/Earth Satellite Corporation

Figure 79: Since the beginning of 2004, NASA has supplied the U.S. Department of Agriculture (USDA) Foreign Agriculture Service with near-real-time data on lake and reservoir water heights from around the world. The USDA posts the data on the Web where anyone interested in crop production, water management, and related areas can access it. For example, the USDA has determined, using data from Jason-1 and TOPEX/Poseidon that Lake Michigan's water height has steadily declined since 1997. This image shows Lake Michigan as seen by Landsat-5 (the path of Jason-1 is depicted by series of points).

Currently, NASA is working with the Department of Defense on a number of joint projects: air-breathing hypersonic propulsion and supporting technologies, such as airframe design and materials and thermal protection systems; communications; conventional rocket-based propulsion development; remote sensing; surveillance; image processing; and advanced computing. NASA also collaborates with the National Oceanic and Atmospheric Administration, the U.S. Geological Survey, and others to ensure public safety and national security through improved climate, weather, and natural hazard forecasting, and more "accurate measurements of land cover, topography, oceans, and atmospheric properties.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 3.1.3[1]: By 2012, in partnership with the Department of Homeland Security, the Department of Defense, and the Department of State, deliver 15 observations and 5 model predictions for climate change, weather prediction and natural hazards to national and global organizations and decision-makers to evaluate 5 scenarios and optimize the use of Earth resources (food, water, energy, etc.) for homeland security, environmental security and economic security.

In FY 2004, NASA continued to collaborate with partner agencies such as the Department of Defense, Department of State, and the Department of Homeland Security to make progress in observing, modeling, and predicting natural and human-induced hazards. The Navy benchmarked use of NASA's Moderate Resolution Imaging Spectroradiometer data in their diver visibility charting tool. And, the Navy used NASA's Scatterometer and Tropical Rainfall Measuring Mission Data for their Severe Weather Forecasting Tool. NASA also worked with the Air Force to give that agency a direct link to the data streams from NASA's Terra and Aqua satellites. The Department of Homeland Security worked with NASA to evaluate the use of NASA-developed air transport and dispersion models for their Interagency Multi-Scale Atmospheric Assessment Center. NASA also provided global measurements to the Climate Change Science Program as input for scientific studies designed to address critical global change and Earth system science questions relevant to our Nation's security.

[1] Note: Due to re-organization within NASA, Outcomes 3.1.1 and 3.1.2 were discontinued with the release of the updated FY 2004 Performance Plan dated February 1, 2004.

Figure 80: The fiscal year on the International Space Station: (left) Expedition 7 Commander Yuri I. Malenchenko (left) and Flight Engineer and Science Officer Edward T. Lu, both wearing Russian Sokol suits on September 4, 2003, completed their stay on the Station in October 2003; (top right) Expedition 8 Flight Engineer Alexander Y. Kaleri (left) and Commander and Science Officer C. Michael Foale, conducting a teleconference with the Moscow Support Group for the Russian New Year celebration on December 28, 2003, were on the Station from October 2003 to April 2004; and (bottom right) Expedition 9 Flight Engineer and Science Officer Edward M. (Mike) Fincke (left) and Commander Gennady I. Padalka, posing with their Russian Orlan spacesuits in the Pirs Docking Compartment on June 10, 2004, arrived on the Station in April 2004 and were scheduled to depart in October.

Outcome 3.1.4: Demonstrate effective international collaboration on the International Space Station.

The International Space Station Partnership maintained a continuous presence of two crewmembers on-board the International Space Station throughout FY 2004. The Expedition 7 crew (Russian Commander Yuri Malenchenko and NASA Flight Engineer Ed Lu) was in residence from April to October 2003. The Expedition 8 Crew (NASA Commander Mike Foale and Russian Flight Engineer Alexander Kaleri) was in residence on-board the Station from October 2003 to April 2004. They were joined by European Space Agency Flight Engineer Pedro Duque from Spain for 1.5 weeks. Duque returned to Earth with the Expedition 7 crew. The Expedition 9 Crew (Russian Commander Gennady Padalka and NASA Flight Engineer Mike Fincke) arrived at the International Space Station in April 2004 with European Space Agency Flight Engineer André Kuipers. Kuipers, a Dutchman, returned to Earth with the Expedition 8 Crew. Throughout this period, the Station crews performed all necessary housekeeping and maintenance activities while conducting a range of scientific investigations.

Outcome 3.1.5: Transfer technology both to and from the Department of Defense.

The sole APG for this outcome (APG 4AT14) was cancelled as a result of funds redistribution due to higher priority activities, including the second flight of the X-43A. The deferral of this activity will have no impact on the primary goal of working partnerships with the Department of Defense. NASA continues to pursue and transfer dual-use technology to and from the Air Force and Army and has instituted an activity to develop dual use rotorcraft technologies. Other significant activity in this area included the successful X-43A hypersonic test flight and the July 12, 2004 initiation of checkout flights for a synthetic vision concept designed for flight at very low altitudes. NASA is developing this technology in conjunction with the Army Aviation Science and Technology

Program. It has applications to both military and civil low altitude flight operations in reduced visibility conditions. NASA also has begun working closely with the Department of Homeland Security and will have joint technology roadmaps available on schedule next year.

Performance Measures for Objective 3.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 3.1.3	By 2012, in partnership with the Department of Homeland Security, the Department of Defense, and the Department of State, deliver 15 observations and 5 model predictions for climate change, weather prediction and natural hazards to national and global organizations and decision-makers to evaluate 5 scenarios and optimize the use of Earth resources (food, water, energy, etc.) for homeland security, environmental security and economic security.	green		Outcomes originated in FY 2004		
APG 4ESA5	Benchmark improvements to at least two of the target national applications—air quality and agricultural competitiveness.	green		3Y29 green	2Y28 green	none
Outcome 3.1.4	Demonstrate effective international collaboration on the International Space Station.	green		Outcomes originated in FY 2004		
APG 4ISS1	In concert with the ISS International Partners, extend a continuous two-person (or greater) crew presence on the ISS through the end of FY 2004.	green		none	none	none
Outcome 3.1.5	Transfer technology both to and from the Department of Defense.	green		Outcomes originated in FY 2004		
APG 4AT14	Conduct and obtain flight test data of autonomous aerial refueling technologies in support of DoD UCAV Program.	white		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 3
Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.

OBJECTIVE 3.2

Improve the Nation's economic strength and quality of life by facilitating innovative use of NASA technology.

WHY PURSUE OBJECTIVE 3.2?

NASA research and development contributes to the Nation's well being in a number of important and sometimes unexpected ways. With its partners, NASA helps protect precious natural resources by measuring and modeling climate and weather, atmospheric properties and air quality, land coverage, and ocean and waterway health.

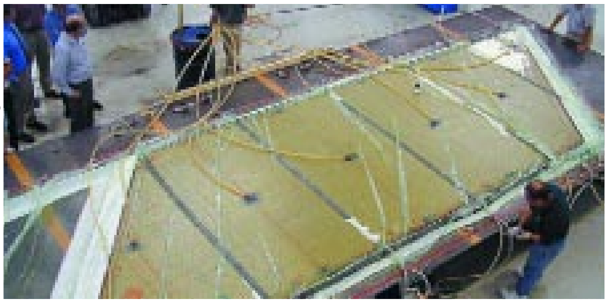

Credit: WebCor Technologies

Figure 81: A commercial company developed this fiber-reinforced foam technology (shown here being used to create a bridge deck panel for the U.S. Navy) with the help of NASA's Ballistic Impact Facility at Glenn Research Center. Through a technology transfer agreement, the company used the facility to make certain that their lightweight foam panels, which are being marketed for use in temporary runways, aircraft parking areas, and other structural surface uses, could withstand high-speed debris impact. In return, NASA may be able to use this strong, lightweight product for rocket fairings, cryogenic tanks, and structural members. For more information on this and other technology transfer agreements, see *Spinoff 2004*.

As a leader in aeronautics and astronautics, NASA collaborates with government and industry to provide faster, more efficient, and safer air transportation. The Agency provides unique tools, facilities, and capabilities for the study and advancement of engineering, physical sciences, biology, materials, and medicine.

NASA also works with government, industry, and academic partners to identify common research objectives and encourages these partners to invest in space research as a means to achieve mutual goals. NASA seeks to couple its technology with private-sector technology to the advantage of both by establishing joint agreements and collaborations to mature technologies and transfer them to the commercial sector where they can benefit the public.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 3.2.1: On an annual basis, develop 50 new technology transfer agreements with the Nation's industrial and entrepreneurial sectors.

In FY 2004, NASA transferred 52 technologies and facility usage agreements to private sector firms in the U.S. The transfers took place through hardware licenses, software usage agreements, or Space Act agreements. Space Act agreements allow NASA to enter into partnerships with various Federal and state agencies, private sector firms, individuals, and educational institutions to meet wide-ranging NASA mission and program requirements and objectives.

Outcome 3.2.2: By 2008, realign commercial product development to focus on NASA needs, while maintaining industrial partnerships.

In FY 2004, NASA worked with its Research Partnership Centers to focus research efforts on dual use opportunities. NASA also reorganized its space product development staff at NASA Headquarters and Marshall Space Flight Center to support and identify new NASA, other Government, and industry partnering opportunities for the Research Partnership Centers. Although NASA's space product development staff and resources helped the Research Partnership Centers in 2004, the Centers themselves must still compete for research and technology development funding. NASA conducted an internal review of the fifteen current Research Partnership Centers to evaluate each Center's potential for success in the newly competitive environment. The review was completed in April 2004, and as a result, three Centers will no longer receive funding beginning in FY 2005.

Outcome 3.2.3: By 2008, develop and test at least two design tools for advanced materials and in-space fabrication, and validate on ISS.

Because of the *Columbia* accident, there were no Shuttle flights to the International Space Station in FY 2004. Once the Shuttle resumes flight, there still will be very limited access to the International Space Station. Since in-space fabrication supports NASA's new Vision for Space Exploration, this Outcome is still viable. However, validation on the International Space Station may not be possible.

Outcome 3.2.4: By 2008, working with all OBPR research organizations and other NASA enterprises, identify at least three additional users of Research Partnership Center spaceflight hardware.

Three researchers from NASA's Exploration Systems Mission Directorate used Research Partnership Center spaceflight hardware in FY 2004. This hardware included the Commercial Generic Bioprocessing Apparatus, the Microgravity Experiment Research Locker, and the Phase Separator. Plans to increase the number of users from the Directorate are in progress.

Outcome 3.2.5: By 2008, increase by 30% (from the 2003 level) the utilization of NASA/OBPR-derived technologies by other agencies, private sector, and academia to advance basic and applied research goals of practical impact.

NASA management dropped this Outcome to support other initiatives that are focused on tasks with greater exploration relevance. As part of the efforts to re-align its resources, NASA is phasing out the following facilities that previously supported this Outcome: Multi-User Gaseous Fuels Apparatus insert for the Combustion Integration Rack; Low-Temperature Microgravity Physics Facility; Quench Module Insert for the Materials Science Research Rack; and the Biotechnology Carrier.

Performance Measures for Objective 3.2		2004 Rating	Past Years' Performance Measures and Ratings		
			2003	2002	2001
Outcome 3.2.1	On an annual basis, develop 50 new technology transfer agreements with the Nation's industrial and entrepreneurial sectors.	green	Outcomes originated in FY 2004		
APG 4HRT6	Complete 50 transfers of NASA technologies, expertise or facility usage to the U.S. private sector, through hardware licenses, software usage agreements, or Space Act agreements.	green	none	none	none
Outcome 3.2.2	By 2008, realign commercial product development to focus on NASA needs, while maintaining industrial partnerships.	green	Outcomes originated in FY 2004		
APG 4RPFS1	Complete realignment plans of SPD.	green	3B9 green	2B11 green	none
APG 4RPFS2	Enable industry research in space that allows them to bring one commercial product under investigation to market by FY 2004.	green	none	none	none
Outcome 3.2.3	By 2008, develop and test at least two design tools for advanced materials and in-space fabrication, and validate on ISS.	yellow	Outcomes originated in FY 2004		
APG 4RPFS3	Complete preparations for launch of a new containerless processing facility for research on synthesis of advanced materials on ISS.	green	none	none	none
APG 4RPFS4	Continue synthesis of zeolite crystals on ISS.	yellow	none	none	none
Outcome 3.2.4	By 2008, working with all OBPR research organizations and other NASA enterprises, identify at least three additional users of Research Partnership Center spaceflight hardware.	green	Outcomes originated in FY 2004		
APG 4RPFS5	Develop a database of RPC spaceflight hardware showing potential outside users.	green	none	none	none
APG 4RPFS6	Develop a system for sharing RPC spaceflight hardware with outside users.	green	none	none	none
Outcome 3.2.5	By 2008, increase by 30% (from the 2003 level) the utilization of NASA/OBPR-derived technologies by other agencies, private sector, and academia to advance basic and applied research goals of practical impact.	white	Outcomes originated in FY 2004		
APG 4PSR1	Maintain an active research program in collaboration with other agencies in laser light scattering, bioreactor, and containerless technologies.	white	none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 3
Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry, and academia.

OBJECTIVE 3.3

Resolve scientific issues in the low gravity environment of space that enrich life on Earth by leading to better design tools in energy, materials, medical, and communication technologies.

WHY PURSUE OBJECTIVE 3.3?

The International Space Station is a unique facility for studying a range of scientific and engineering questions without the obscuring effects of gravity. It is the only facility where investigators can conduct hands-on, long-duration research in a true microgravity environment. NASA is working with its national and international partners to give investigators access to the Station and other space facilities and to promote the academic and commercial benefits of space-based research. Space research—enabled by research grants, commercial partnerships, and other types of agreements—contributes to a number of economically and socially important areas, including fluid, thermal, and combustion engineering science, materials research, fundamental biology, biotechnology, communications, energy production and storage, and medicine.

Figure 82: Expedition 8 Commander and Science Officer C. Michael Foale (foreground) and European Space Agency astronaut Andre Kuipers of the Netherlands work with an experiment in the Microgravity Science Glovebox in the Station's Destiny Laboratory on April 22, 2004. During the fiscal year, the Station was used to conduct research from several International Space Station partner nations.

Partnerships between NASA, industry, academia, and other government entities give to all involved access to a wider range of knowledge and capabilities. These partnerships also provide excellent opportunities to leverage the limited space flight experiment availability and a natural way for research and technology to be matured and transferred to the public.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 3.3.1: By 2008, analyze the impact of the results of the first phase of ISS and ground-based research in Biotechnology, fundamental science, and engineering to demonstrate the introduction of at least two new design tools and/or process improvements to existing technologies and industrial practices.

NASA management dropped this Outcome to support other initiatives that are focused on tasks with greater exploration relevance. As part of the efforts to re-align its resources, NASA is phasing out the following facilities that previously supported this Outcome: Multi-User Gaseous Fuels Apparatus insert for the Combustion Integration Rack; Low-Temperature Microgravity Physics Facility; Quench Module Insert for the Materials Science Research Rack; and the Biotechnology Carrier.

Outcome 3.3.2: By 2008, quantitatively assess the impact of space and ground-based research on fire safety hazard prevention and containment and on energy conversion to demonstrate measurable risk reduction and increased efficiency.

Fire safety in space, and on the ground, remains an important Agency research area. Learning more about fire leads to better ways to control fire and combustion which, in turn, saves lives, property and money. In FY 2004, NASA continued to process and analyze data retrieved from Space Shuttle *Columbia* on fire safety and microgravity combustion.

Outcome 3.3.3: By 2008, develop at least three new leveraged research partnerships with industry, academia, and other government agencies that improve NASA spacecraft safety.

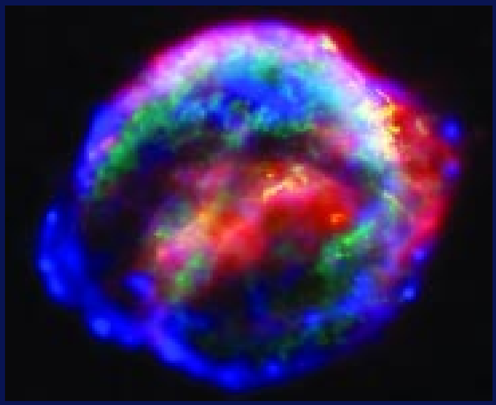
NASA currently is solidifying several partnerships in research applicable to spacecraft safety and is developing several technologies and tools for safer spacecraft. These include: a fire suppression device for new spacecraft (e.g., the Crew Exploration Vehicle) and for planetary habitats (e.g., research bases on the Moon and Mars); a lightweight, pointable, hyperspectral sensor to detect environmental contaminants (e.g., toxins, leaks); an integrated surveillance system for physiological sensing on astronauts, (e.g., heart rate, basal metabolic rate); and a prototype monitoring and communication system for integration into astronauts' Extra Vehicular Activity space suits.

Performance Measures for Objective 3.3		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 3.3.1	By 2008, analyze the impact of the results of the first phase of ISS and ground-based research in biotechnology, fundamental science, and engineering to demonstrate the introduction of at least two new design tools and/or process improvements to existing technologies and industrial practices.	white		Outcomes originated in FY 2004		
APG 4PSR2	Demonstrate the productivity of the research program in combustion, fluids physics, biotechnology, and materials science and accomplish the milestones of ISS research projects.	white		none	none	none
Outcome 3.3.2	By 2008, quantitatively assess the impact of space and ground-based research on fire safety hazard prevention and containment and on energy conversion to demonstrate measurable risk reduction and increased efficiency.	green		Outcomes originated in FY 2004		
APG 4PSR3	Process and analyze existing STS-107 data on fire safety and microgravity combustion research and maintain a productive ground and flight-based research program.	green		3B6 yellow	2B8 green	none
Outcome 3.3.3	By 2008, develop at least three new leveraged research partnerships with industry, academia, and other government agencies that improve NASA spacecraft safety.	green		Outcomes originated in FY 2004		
APG 4RPFS7	Develop at least one enabling technology to improve the safety of space transportation systems.	green		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Mission: To Explore the Universe and Search for Life

Goal 4: Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.



Goal 5: Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

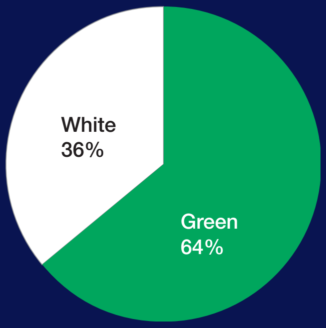
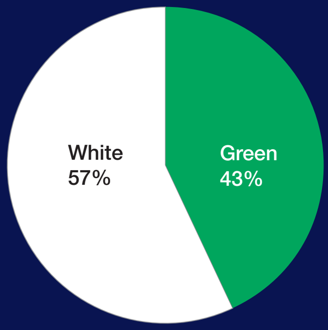


Figure 83: NASA achieved 64 percent of the APGs in Goal 4.



NASA is on track to achieve 43 percent of its Outcomes under Goal 4.

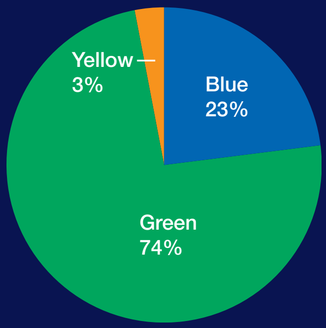
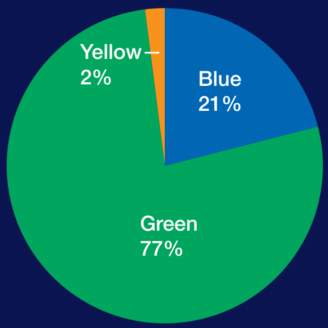


Figure 84: NASA achieved 97 percent of the APGs in Goal 5.



NASA is on track to achieve 98 percent of its Outcomes under Goal 5.

APG color ratings:

Blue:	Significantly exceeded APG
Green:	Achieved APG
Yellow:	Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
Red:	Failed to achieve APG, do not anticipate completion within the next fiscal year.
White:	APG was postponed or cancelled by management directive.

Outcome color ratings:

Blue:	Significantly exceeded all APGs. On track to exceed this Outcome as stated.
Green:	Achieved most APGs. On track to fully achieve this Outcome as stated.
Yellow:	Progress toward this Outcome was significant. However, this Outcome may not be achieved as stated.
Red:	Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
White:	This outcome as stated was postponed or cancelled by management directive or the Outcome is no longer applicable as stated based on management changes to the APGs.

Goal 4
Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.

OBJECTIVE 4.1

Determine how fundamental biological processes of life respond to gravity and space environments.

WHY PURSUE OBJECTIVE 4.1?

Life on Earth evolved in response to Earth's gravity and protective environment. But what happens to living systems when they are transported to space? This question is key as humans seek to venture past the protection of Earth to explore the Moon, Mars, and beyond.

Figure 85: NASA uses this tiny worm, *C. elegans*, to study how organisms respond to gravity at the molecular, cellular, developmental, and behavioral levels. *C. elegans* last flew aboard the International Space Station during Expedition 9 in 2004 as part of the International Caenorhabditis Elegans first international biology experiment (ICE-First), a collaborative research project involving the United States, France, Japan, and Canada.

NASA is conducting fundamental biological research on how terrestrial life (e.g., cells, bacteria, insects, plants, animals) form, organize, grow, and function in space. NASA seeks answers to questions about changes at the physical, chemical, molecular, and cellular level—changes affecting the whole organism. NASA also is studying the complex interaction of multiple species in closed environments and exploring answers to the following critical questions:

- Does space affect life at its most fundamental levels, from the gene to the cell?
- How does long-term exposure to space affect organisms?
- How does space affect the life cycles of organisms from one to many generations?
- How do systems of organisms change in space?

While this research will provide critical strategic information for human exploration, it also will provide new information on life in general.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 4.1.1: Use ground-based simulators and ISS to determine gravity responses for at least five model organisms by 2008.

NASA solicited a number of research proposals from the science community to conduct ground-based studies on model organisms. The research to be conducted will focus on both plant and microbial organisms. NASA also participated in the "International Plant Workshop" which established a research roadmap and goals, and the "Animal Research in Support of Human Space Exploration" workshop, which resulted in recommendations of optimal model organisms for different biomedical problems. NASA also continued its active, ongoing hypergravity research program at Ames Research Center's Center for Gravitational Biology Research.

Outcome 4.1.2: Develop predictive models of cellular, pathogenic, and ecological responses to space for at least two organisms by 2008.

NASA continued to make satisfactory progress towards its 2008 goal for this Outcome by soliciting a number of research proposals from the science community to research and develop predictive models for model organisms. The research will focus on both plant and microbial organisms. In FY 2004, NASA researchers also participated in, and/or organized, a number of workshops, including: "Animal Research in Support of Human Space Exploration," "Office of Biological and Physical Research Microbial Models," "What do you need to know about Cell Biology Experiments in Space," and the "NASA Cell Science Conference Annual Investigator Workshop."

Outcome 4.1.3: By 2008, structure the Fundamental Space Biology flight research program to emphasize at least five model organisms and teams of Principal Investigators. Working towards NASA's 2008 goal for this Outcome, the Agency solicited a number of research proposals from the science community to research four model organisms. NASA and the International Space Life Sciences Working Group will form research teams prioritized according to Critical Path Roadmap Risks and NASA's Vision for Space Exploration. NASA also completed a re-evaluation of International Space Station and Shuttle flight hardware and habitats with respect to research goals and resources. In the area of cell science, research will focus on hardware that is already on-orbit or which will be completed this fiscal year (e.g., commercial incubator and cellular biotechnology incubator, Single Loop Cell Culture). These experiments have not yet been manifested for flight, but they are planned to begin in FY 2005. In the area of animal research, NASA will continue to use Animal Enclosure Modules on the Shuttle's middeck. This hardware has supported rodent research since the late 1980s. NASA also is identifying the critical questions and risks that should have the highest priority for study on the International Space Station when the Advanced Animal Habitat and Centrifuge become available. In the area of plant research, NASA has focused International Space Station plant research on the European Modular Cultivation System, which has a variable gravity centrifuge that will be used to simulate lunar and Martian gravity. The first of these experiments will be conducted no earlier than International Space Station Increment 11, following the second return to flight mission in July 2005.

Performance Measures for Objective 4.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 4.1.1	Use ground-based simulators and ISS to determine gravity responses for at least five model organisms by 2008.	green		Outcomes originated in FY 2004		
APG 4BSR1	Solicit ground-based research on two widely studied model organisms.	green		none	none	none
APG 4BSR2	Produce a road map and strategic goals for plant research ground-based studies and flight opportunities. Solicit flight-based research on at least one model plant species.	green		none	none	none
Outcome 4.1.2	Develop predictive models of cellular, pathogenic, and ecological responses to space for at least two organisms by 2008.	green		Outcomes originated in FY 2004		
APG 4BSR3	Solicit ground-based research on responses of cells and pathogens to space environments.	green		none	none	none
APG 4BSR4	Select two model species to support the development of predictive models. Communicate with the research community in workshops and at national and international scientific meetings about the approach.	green		none	none	none
Outcome 4.1.3	By 2008, structure the Fundamental Space Biology flight research program to emphasize at least five model organisms and teams of Principal Investigators.	green		Outcomes originated in FY 2004		
APG 4BSR5	In coordination with International partners, solicit flight research on two model organisms and establish at least two research teams.	green		none	none	none
APG 4BSR6	Review and reprioritize Fundamental Space Biology flight experiments with a focus on model specimens.	green		none	none	none
APG 4BSR7	Reevaluate flight hardware and habitats with respect to research goals and focus resources on select units.	green		none	none	none

Goal 4
Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.

OBJECTIVE 4.2

Expand understanding of fundamental physical processes and insight into the laws of nature through space-based investigation.

WHY PURSUE OBJECTIVE 4.2?

Gravity affects everything humans do on Earth. It molds living things and influences the physical processes occurring around the globe. But gravity also blinds humans to a realm of other, more subtle forces that drive the physical world. NASA is using its unique resources to study these “secondary” forces. By studying the physical forces that regulate the behavior of fluids, gases, and solids, researchers gain new insights into the areas of materials processing, propulsion, energy production and storage, chemistry, biotechnology, biology, communications, combustion, and others. NASA researchers also are gaining a better understanding of nature’s complexity and how order arises from seemingly chaotic interactions. The synergy and vigor achieved through NASA’s interdisciplinary research into fundamental physical processes helps the Agency meet its exploration goals and ensures that NASA’s contribution to fundamental research is at the leading edge of science.

Figure 86: Expedition 9 Science Officer Mike Fincke works with equipment for the Binary Colloidal Alloy Test-3 experiment in the Station’s Destiny Laboratory on April 27, 2004. The experiment studied the long-term behavior of colloids—a system of fine particles suspended in a fluid like paint or milk—in a low gravity environment.

NASA’S PROGRESS AND ACHIEVEMENTS IN FY 2004

In FY 2004, NASA management dropped the four Outcomes under this Objective to support other initiatives that are focused on tasks with greater exploration relevance. As part of the Agency’s effort to realign resources, NASA terminated the Low-Temperature Microgravity Physics Facility that supported Outcomes 4.2.1, 4.2.2, and 4.2.3. Because of the realignment of the Biotechnology program, NASA also terminated the International Space Station Biotechnology facility that previously supported Outcome 4.2.4.

Objective 4.2 was continued in NASA's FY 2005 Integrated Budget and Performance Document (Performance Plan). These Outcomes will be reconsidered based on resource availability and Agency priorities in FY 2005 and beyond.

Outcome 4.2.1: By 2008, complete the first generation of ISS research in colloidal physics and soft condensed matter and demonstrate the ability to control the colloidal engineering of at least two different model structures.
Deferred until FY 2005.

Outcome 4.2.2: By 2008, complete the design and fabrication of the first ISS fundamental microgravity physics facility to allow the performance of two capstone investigations in dynamical critical phenomena.
Deferred until FY 2005.

Outcome 4.2.3: By 2008, complete the design for the ISS laser-cooling laboratory and demonstrate the feasibility to deploy the most accurate atomic clock in space.
Deferred until FY 2005.

Outcome 4.2.4: By 2008, complete the first phase of the ISS biotechnology facility and demonstrate cellular biotechnology research throughput increase by a factor of two.
Deferred until FY 2005.

Performance Measures for Objective 4.2		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 4.2.1	By 2008, complete the first generation of ISS research in colloidal physics and soft condensed matter and demonstrate the ability to control the colloidal engineering of at least two different model structures.	white		Outcomes originated in FY 2004		
APG 4PSR4	Demonstrate the productivity of the colloidal physics and soft-condensed matter program and accomplish the planned ISS research projects milestones.	white		none	none	none
Outcome 4.2.2	By 2008, complete the design and fabrication of the first ISS fundamental microgravity physics facility to allow the performance of two capstone investigations in dynamical critical phenomena.	white		Outcomes originated in FY 2004		
APG 4PSR5	Demonstrate the accomplishments of the ISS fundamental physics facility development milestones and maintain a productive ground and space-based research program in condensed matter physics.	white		none	none	none
Outcome 4.2.3	By 2008, complete the design for the ISS laser-cooling laboratory and demonstrate the feasibility to deploy the most accurate atomic clock in space.	white		Outcomes originated in FY 2004		
APG 4PSR6	Demonstrate the accomplishments of the ISS laser cooling and atomic physics facility milestones and maintain an innovative and productive ground and space-based research program in atomic and gravitational physics.	white		3B5 green	2B7 green	none
Outcome 4.2.4	By 2008, complete the first phase of the ISS biotechnology facility and demonstrate cellular biotechnology research throughput increase by a factor of two.	white		Outcomes originated in FY 2004		
APG 4PSR7	Demonstrate the accomplishments of the ISS biotechnology research facility development milestones and maintain a productive and innovative ground and space-based research program in cellular biotechnology and tissue engineering.	white		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.1

Learn how the solar system originated and evolved to its current diverse state.

WHY PURSUE OBJECTIVE 5.1?

Earth's solar system is a place of beauty, and continuous change. The Sun's planets have numerous moons with diverse characteristics, and each tells a story about the evolution of the solar system. Within the first billion years of the solar system's five-billion-year history, the planets formed and life began to emerge on Earth and, perhaps, elsewhere. Many of the current characteristics of the solar system were determined during this critical formative epoch.

Credit: NASA JPL/Caltech

Figure 87: The Stardust spacecraft, shown here in an artist's rendition, successfully flew through the coma of comet Wild 2 in January 2004. During its rendezvous, it captured interstellar dust samples and stored them in aerogel, a silica-based material, for their trip back to Earth. Comets, which scientists believe are the oldest, most primitive objects in the solar system, may have left the first water on Earth.

The planets, moons, and ancient icy bodies that reside far from the Sun are thought to be a repository of relatively pristine materials from this time, and therefore, hold keys that can help unlock the mysteries of the solar system's origins. NASA is gaining a better understanding of the evolution of the solar system through outer solar system exploration and through the surface exploration and return of samples from the inner planets and small bodies. NASA's exploration of this solar system also will provide insight into the formation of other solar systems.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.1.1 through 5.1.4 and determined that NASA successfully demonstrated progress in all four Outcomes during FY 2004.

Outcome 5.1.1: Understand the initial stages of planet and satellite formation.

A number of NASA's initiatives contributed to the Agency's progress, including the Stardust mission, the Genesis mission, and NASA's Planetary Astronomy program.

- NASA's Stardust mission successfully flew through the coma of comet Wild 2 on January 2, 2004 and collected approximately three times the amount of cometary dust expected. Cometary dust is the mineral portion of the material that formed the outer planets (Jupiter, Saturn, Uranus, and Neptune). Stardust will return its sample of comet dust to Earth in January 2006 for detailed laboratory analysis.

- NASA's Genesis spacecraft successfully completed its 22-month phase of collecting solar wind particles in April 2004. Scientists theorize that solar wind particles might accurately preserve the original mix of elements (atoms) that formed the Sun and planets. Genesis returned its samples to Earth in September 2004. Although the soft landing was unsuccessful, researchers are optimistic that the bulk of the samples will be viable for detailed laboratory analysis.
- Researchers funded by NASA's Planetary Astronomy program discovered the most distant object found to date in the solar system. Tentatively named "Sedna," this object, between 800 and 1100 miles in diameter, is somewhat smaller than Pluto. It orbits the Sun in a highly eccentric path that approaches within 8 billion miles of the Sun (over twice Pluto's average distance) at its closest, but recedes to 84 billion miles at its farthest during its 10,500-year orbital period.

Outcome 5.1.2: Understand the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact.

Two major activities contributed to NASA's progress in this Outcome: NASA's Cassini mission; and the proposed Jupiter Icy Moons Orbiter mission. First, NASA's Cassini spacecraft successfully entered Saturn's orbit and returned images of Saturn's rings that revealed waves of various types, scalloped ring edges, and braiding not seen by previous planetary spacecraft. These highly detailed images greatly enhanced researchers' ability to understand the nature and evolution of ring systems. Second, the Jupiter Icy Moons Orbiter Science Definition Team formulated four primary goals for its mission, including objectives and measurements. Initial studies for the Jupiter Icy Moons Orbiter mission are underway. The mission will use nuclear electric power and propulsion to enable comprehensive exploration of Jupiter's icy moons (Europa, Ganymede, and Callisto), to acquire extensive observations of Jupiter, Io, and other bodies, and to investigate the dynamics and processes at work in Jupiter's system.

Outcome 5.1.3: Understand why the terrestrial planets are so different from one another.

The launch of the MESSENGER mission and improvements in planetary simulations contributed to NASA's progress in this Outcome. NASA's MESSENGER mission to Mercury launched successfully on August 3, 2004. MESSENGER will conduct a comprehensive geological, geophysical, and geochemical survey of the planet Mercury. NASA researchers also used novel numerical techniques to show diversity in terrestrial planet sizes, positions, and sources of water to simulate this and other solar systems.

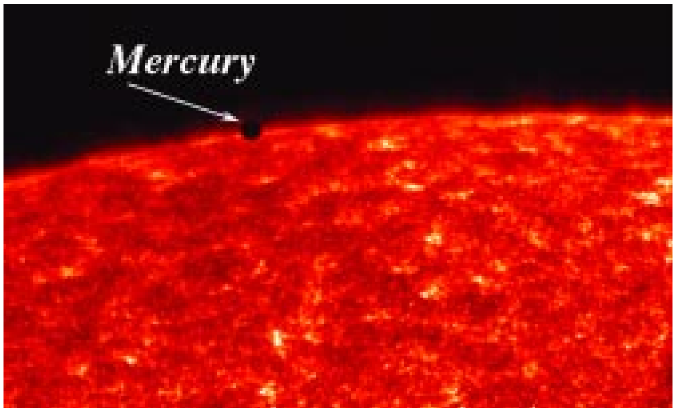


Figure 88: The MESSENGER spacecraft will visit Mercury, the innermost planet of this solar system, shown here in an image (taken by the TRACE satellite in Earth orbit) of the terrestrial planet during solar transit on November 15, 1999.

Preliminary results indicate that the amount of gas present when planets form determines whether Earth-sized or Mars-sized planets form. These simulations provide predictions that can be tested with future Mars and Venus missions, as well as missions designed to search for planets around other stars.

Outcome 5.1.4: Learn what our solar system can tell us about extra-solar planetary systems.

NASA researchers revealed that Jupiter and Saturn's positions relative to each other might reflect dynamic processes common to planetary systems. Theoretical studies, together with the existence of at least one extra-solar planetary system, suggest that the 5:2 ratio of the orbit periods of Jupiter and Saturn might be a common relationship between two giant planets. This also implies that giant planets migrating inward during solar system formation might naturally end up in special orbital relationships like that of Jupiter and Saturn.

Performance Measures for Objective 5.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.1.1	Understand the initial stages of planet and satellite formation.	yellow		Outcomes originated in FY 2004		
APG 4SSE12	Successfully demonstrate progress in understanding the initial stages of planet and satellite formation. Progress towards achieving outcomes will be validated by external review.	yellow		none	none	none
Outcome 5.1.2	Understand the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact.	green		Outcomes originated in FY 2004		
APG 4SSE13	Successfully demonstrate progress in studying the processes that determine the characteristics of bodies in our solar system and how these processes operate and interact. Progress towards achieving outcomes will be validated by external review.	green		3S3 green	2S3 green	none
Outcome 5.1.3	Understand why the terrestrial planets are so different from one another.	green		Outcomes originated in FY 2004		
APG 4SSE14	Successfully demonstrate progress in understanding why the terrestrial planets are so different from one another. Progress towards achieving outcomes will be validated by external review.	green		3S5 green	2S5 green	1S10 blue
Outcome 5.1.4	Learn what our solar system can tell us about extra-solar planetary systems.	green		Outcomes originated in FY 2004		
APG 4SSE15	Successfully demonstrate progress in learning what our solar system can tell us about extra-solar planetary systems. Progress towards achieving outcomes will be validated by external review.	green		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

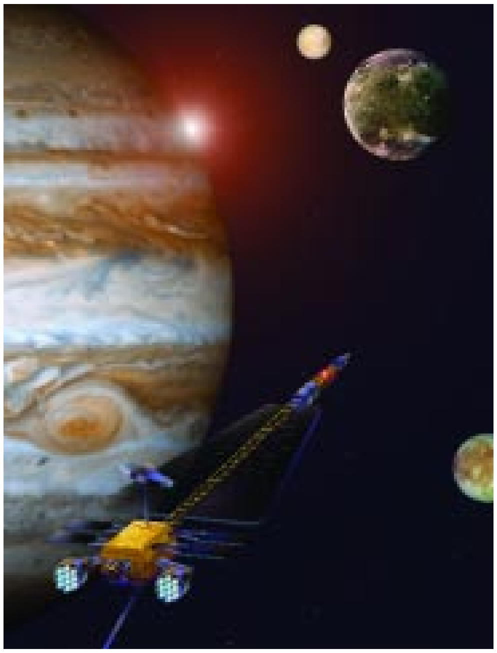
Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.2

Understand how life begins and evolves and determine the characteristics of the solar system that led to the origin of life.

WHY PURSUE OBJECTIVE 5.2?

The essential requirements for life on Earth are organic material, liquid water, and a source of usable energy. The availability of all these ingredients defines whether or not a planet is "habitable." The "habitable zone" of a solar system is defined as the region harboring habitable planets. Scientists once thought that the habitable zone of the solar system was limited, primarily by a need for the right amount of sunlight, to a fairly narrow region around Earth's distance from the Sun. The discovery that great tides on Europa, an icy moon of Jupiter, heat the planet's interior and create a liquid ocean under its ice-bound surface, and the discovery on Earth of microbial life-forms that survive and thrive at extremely high and low temperatures and in extreme acidity, salinity, alkalinity, and concentrations of heavy metals that were once considered lethal, have expanded scientists' views regarding the range of conditions capable of supporting life and what constitutes habitable zones in this solar system and beyond.



Credit: NASA JPL/Caltech

Figure 88: The Jupiter Icy Moons Orbiter, shown here in an artist's concept, will visit Callisto, Ganymede, and Europa, each of which have the three ingredients considered essential for life: water, energy, and the necessary chemical contents. The mission will investigate the moons to find out more about their makeup, history, and potential for sustaining life.

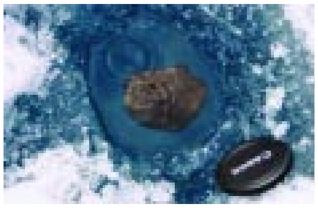
NASA is studying Earth's geological and biological records to determine the historical relationship between Earth and its living organisms. From this, NASA is seeking to determine the sources of organic compounds that could lead to life and to understand their roles in the processes that take place on any newly formed planet. NASA also is planning and conducting missions to planetary bodies in the solar system, including Mars and three moons of Jupiter, that may harbor some of the key components necessary for life.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.2.1 through 5.2.4 and determined that NASA successfully demonstrated progress in all four Outcomes during FY 2004.

Outcome 5.2.1: Determine the nature, history, and distribution of volatile and organic compounds in the solar system.

Recent research indicates miniscule interplanetary dust particles and meteorites collected from Earth's stratosphere by NASA aircraft since the mid-1970s contain significant concentrations of simple hydrocarbons and have not been altered much by contact with water. This indicates that pre-biotic organic matter was abundant in the early solar system and formed prior to the incorporation of interplanetary dust particles into asteroids and comets. Researchers studying the



Credit: University of Calgary/University of Western Ontario

Figure 89: The Tagish Lake meteorite, shown here next to a camera lens cap for scale, contains the oldest organic materials—tiny bits of interstellar dust—ever found. Its materials provide clues to the solar system's formation approximately 4.6 billion years ago. The meteorite plummeted to Earth and landed on a frozen lake in British Columbia, Canada, in January 2000.

Tagish Lake meteorite, which fell in Canada in January 2000, identified microscopic globules of organic material with compositions that indicate they formed from pre-solar materials. These are the oldest organic compounds yet discovered. Further study of these globules should provide important clues about chemical reactions in the cold molecular clouds from which stars form and the processes present in the early solar system. The NASA Cosmochemistry Program partly funded these international studies.

Outcome 5.2.2: Identify the habitable zones in the solar system.
Activities contributing to NASA's progress included discoveries by the twin Mars rovers (*Spirit* and *Opportunity*) and experiments in Chile's Atacama Desert. *Opportunity* found evidence that portions of Mars may have had habitable environments in the past. At its landing site within a small crater in Meridiani Planum, *Opportunity* discovered unambiguous evidence that ponds (and perhaps larger bodies) of salty water stood at that location long enough to produce sedimentary rocks. It found this evidence in the uppermost (and therefore, geologically, the most recent) sediment layers. Meanwhile, in Chile's Atacama Desert, experiments patterned after the Viking biology experiment, and funded by the NASA Astrobiology program, showed active non-biological decomposition of organic chemicals in those soils. Researchers conducted these studies in the Atacama Desert because some areas of the desert are so dry that no indigenous life is found; its dry soils lack organics and show the presence of one or more reactive oxidants. Studies like this help researchers understand analyses of other planets.

Outcome 5.2.3: Identify the sources of simple chemicals that contribute to pre-biotic evolution and the emergence of life.
NASA made significant progress in understanding the basic sugars present in the molecules that make up RNA and DNA, the molecules that carry the genetic codes for all life on Earth. Ribose is a type of sugar that forms the "backbone" of RNA and DNA. The formation of ribose appears to be a natural outcome of chemical transformation of non-biological organic molecules that were present in the earliest stages of the solar system's formation. Ribose is chemically unstable in liquid water. However, recent studies funded by the NASA Astrobiology program revealed that borate minerals (like the common household cleaner borax) stabilize ribose in water. Consequently, ribose could have formed by non-biological chemical processes in water before life emerged on Earth, a finding that would overcome a longstanding hurdle in understanding the emergence of life on Earth.

Outcome 5.2.4: Study Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere.
Two hundred fifty million years ago, the Permian geological era ended with the greatest mass extinction in Earth's history: more than 90 percent of marine species and more than 70 percent of terrestrial species perished. Suggestions that it was caused by a massive impact of an asteroid or comet gained support recently when researchers identified a geological structure named Bedout, offshore of northwestern Australia, as a potential impact crater. Research funded jointly by the National Science Foundation and the NASA Astrobiology program identified evidence of impact in cores taken from the Bedout structure. In other research, scientists revealed that identifying the nature of the last universal common ancestor of life might be impossible. The patterns of coalescence of genetic sequence data indicates that different genes trace back to ancestors of different ages, so, there may have been no single last common ancestor of all genetic sequences. Distinguishing between asteroid impacts and massive volcanic activity as the cause of large extinctions on Earth is difficult because of the possibility that large impacts cause large-scale volcanic events. A NASA-funded theoretical study using detailed computer modeling of impacts and their effects on the Earth's crust determined that impacts must be so large in order to trigger large-scale volcanic flows that the two mechanisms for global extinction must be considered as separate possible causes rather than as coupled causes.

Performance Measures for Objective 5.2		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.2.1	Determine the nature, history, and distribution of volatile and organic compounds in the solar system.	green		Outcomes originated in FY 2004		
APG 4SSE16	Successfully demonstrate progress in determining the nature, history, and distribution of volatile and organic compounds in the solar system. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.2.2	Identify the habitable zones in the solar system.	green		Outcomes originated in FY 2004		
APG 4SSE17	Successfully demonstrate progress in identifying the habitable zones in the solar system. Progress towards achieving outcomes will be validated by external review.	green		3S6 green	2S6 green	none
Outcome 5.2.3	Identify the sources of simple chemicals that contribute to pre-biotic evolution and the emergence of life.	green		Outcomes originated in FY 2004		
APG 4SSE18	Successfully demonstrate progress in identifying the sources of simple chemicals that contribute to prebiotic evolution and the emergence of life. Progress towards achieving outcomes will be validated by external review.	green		3S6 green	2S6 green	none
Outcome 5.2.4	Study Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere.	green		Outcomes originated in FY 2004		
APG 4SSE19	Successfully demonstrate progress in studying Earth's geologic and biologic records to determine the historical relationship between Earth and its biosphere. Progress towards achieving outcomes will be validated by external review.	green		none	none	none

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.3

Understand the current state and evolution of the atmosphere, surface, and interior of Mars.

WHY PURSUE OBJECTIVE 5.3?

Mars holds a special place in the solar system by virtue of its similarities to Earth, its potential f or having been a home for life, and its value as a "natural laboratory" for understanding the environmental and geological evolution of the rocky planets of the inner solar system. Mars' atmosphere, surface, and interior, and their interactions with one another, can tell researchers much about the environment in which life could have developed and thrived. By characterizing these interactions, researchers also gain insight into the conditions that could spawn and support life elsewhere in the universe.

Credit: NASA JPL/Cornell

Figure 90: The Mars rover *Opportunity* took this picture of a rock called "Berry Bowl" in the Eagle Crater outcrop in March 2004. The surrounding area is strewn with sphere-like granules, called "blueberries," that contain hematite that was deposited in the rock by water that once flowed on Mars.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.3.1 through 5.3.4 and determined that NASA successfully demonstrated progress in all four Outcomes during FY 2004. In two of the Outcomes (5.3.2 and 5.3.3), the Space Science Advisory Committee recommended a "blue" rating indicating exceptional achievement (e.g., results of major importance or significant unexpected discoveries), relative to resources invested in those research focus areas.

Outcome 5.3.1: Characterize the present climate of Mars and determine how it has evolved over time.

NASA researchers gained a new view of the climate history of Mars thanks to more than two Mars years (one Mars year is equal to 687 Earth days) of observations from Mars Global Surveyor and new boundary conditions provided by Mars Odyssey. This new synthesis of data emphasizes the possibility of an active water cycle resulting in snow and ice on the surface during the most recent climate cycles on the planet.

Outcome 5.3.2: Understand the history and behavior of water and other volatiles on Mars.

The successful mission of the Mars Exploration Rovers, *Spirit* and *Opportunity*, that landed on Mars, completed their 90-day prime missions successfully, and continue to explore the Martian surface, contributed to NASA's exceptional progress in this Outcome. *Spirit* found evidence that small amounts of water had been present in cracks in the rocks and in the soil on the floor of Gusev crater. *Opportunity* found evidence that standing pools of water once existed in Meridiani Planum. *Spirit* is currently examining a low range of hills that are revealing additional clues to past conditions in Gusev crater. The Mars Global Surveyor also uncovered the first evidence of a former river delta on Mars. This fan-shaped apron of debris indicates persistent flow of water over a period that lasted from thousands to millions of years.

Credit: NASA JPL/Malin Space Science Systems

Figure 91: In November 2003, the Mars Global Surveyor took several images that shows where a meandering stream was cut-off as the channel adjusted its course. The image series, taken of a crater at 24.3°S, 33.5°W, shows the first evidence of an ancient river delta on Mars.

Outcome 5.3.3: Understand the chemistry, mineralogy, and chronology of Martian materials.

Quantitative assessments of dozens of Martian soil samples and rocks produced by the Mars Exploration Rovers *Spirit* and *Opportunity* contributed to NASA's exceptional progress in this Outcome. NASA was able to link the analyses of the chemical and mineral compositions of the various soils and rocks in two distinctly different locations on Mars to orbital remote sensing data from Mars Odyssey and Mars Global Surveyor. An analysis of crater images in Meridiani Planum showed that these deposits were at the top of a 300-meter thick sequence of layers that overlies Noachian (the earliest geological era on Mars) cratered terrain. Further analysis produced strong evidence for significant erosion, probably by wind-driven processes, much later in time. Mars Odyssey also completed a global mapping of Mars elements with its Gamma Ray Spectrometer suite, providing an assessment of the bulk chemical composition of the Martian crust at regional scales.

Outcome 5.3.4: Determine the characteristics and dynamics of the interior of Mars.

Studies of Martian meteorites funded by NASA's Cosmochemistry program revealed distinctive mineral reservoirs in the Martian mantle (the layer below Mars' surface or "crust") that were established when the mantle solidified 4.5 billion years ago. This meteorite work provides a fundamental framework for interpreting global data obtained by remote sensing satellites in Mars orbit.

Performance Measures for Objective 5.3		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.3.1	Characterize the present climate of Mars and determine how it has evolved over time.	green		Outcomes originated in FY 2004		
APG 4MEP9	Successfully demonstrate progress in characterizing the present climate of Mars and determine how it has evolved over time. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.3.2	Understand the history and behavior of water and other volatiles on Mars.	blue		Outcomes originated in FY 2004		
APG 4MEP10	Successfully demonstrate progress in investigating the history and behavior of water and other volatiles on Mars. Progress towards achieving outcomes will be validated by external review.	blue		none	none	none
Outcome 5.3.3	Understand the chemistry, mineralogy, and chronology of Martian materials.	blue		Outcomes originated in FY 2004		
APG 4MEP11	Successfully demonstrate progress in studying the chemistry, mineralogy, and chronology of Martian materials. Progress towards achieving outcomes will be validated by external review.	blue		none	none	none
Outcome 5.3.4	Determine the characteristics and dynamics of the interior of Mars.	green		Outcomes originated in FY 2004		
APG 4MEP12	Successfully demonstrate progress in determining the characteristics and dynamics of the interior of Mars. Progress towards achieving outcomes will be validated by external review.	green		none	none	none

Goal 5 Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.4

Determine if life exists or has ever existed on Mars.

WHY PURSUE OBJECTIVE 5.4?

In 1877, Italian astronomer Giovanni Virginio Schiaparelli announced that he had observed "canali," linear markings, on the surface of Mars. Although "canali" means "channels" in Italian, poor translations led some to believe that Martian inhabitants had built canals across the surface of Mars. Since then, the concept of life on Mars has been a popular theme in literature, films, and television. But, is the concept more than science fiction? The discovery of life, past or present, on Mars would be a defining moment for humankind.

Credit: NASA JPL/Cornell

Figure 92: The rover *Spirit* used its abrasion tool to take samples of a relatively soft rock called "Wooly Patch" near the base of "Columbia Hills" inside the Gusev Crater on July 30, 2004. Scientists speculate that this relatively soft rock (compared to others analyzed by *Spirit*) may have been modified by water. Small cracks in the surface outside the drill holes may be the result of interactions with water-rich fluids. In addition to searching for signs of water, the rovers are analyzing the chemical composition of the Martian surface to try to determine its history and its potential for supporting life.

NASA missions have revealed that water once flowed over Mars' surface. NASA also is studying the surface and Mars meteorites found on Earth for the presence of organic materials and chemical indicators of life. There may be present-day niches on Mars that are hospitable to life or specific deposits that have preserved chemicals that indicate that Martian life could have—or did—exist.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.4.1 and 5.4.2 and determined that NASA successfully demonstrated progress in both Outcomes during FY 2004.

Outcome 5.4.1: Understand the character and extent of prebiotic chemistry on Mars.

The overarching goal of the Mars Science Laboratory rover, scheduled for launch in 2009, will be to explore and quantitatively assess the Martian surface as a habitat for life, past, present, or future. Its instruments will be capable of identifying organic compounds and its measurements will contribute to our evaluation of probable prebiotic chemistry on Mars. NASA released the solicitation for Mars Science Laboratory rover instruments in FY 2004.

Outcome 5.4.2: Search for chemical and biological signatures of past and present life on Mars.

NASA's progress included discoveries by the Mars Exploration Rovers and researching a shared system for samples collected on the Mars surface. The rover *Opportunity* discovered evaporite minerals suggesting at least one surface location that is promising for the search for past or present Martian life. This year, NASA also conducted a study to identify the issues and feasibility of a shared system for Mars surface sample preparation and distribution. The system would

Figure 93: The sun sets on Mars as the Mars Science Laboratory rover continues to explore in this artist concept. The mission is planned for launch in 2009.

provide common functions for: receiving a variety of sample types from multiple sample acquisition systems; conducting preliminary analysis of these samples with non-destructive science instruments and making decisions about what should happen to the samples; performing a variety of sample preparation functions; and, finally, sharing the prepared samples with additional science instruments for further analysis.

Performance Measures for Objective 5.4		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.4.1	Understand the character and extent of prebiotic chemistry on Mars.	green		Outcomes originated in FY 2004		
APG 4MEP13	Successfully demonstrate progress in investigating the character and extent of prebiotic chemistry on Mars. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.4.2	Search for chemical and biological signatures of past and present life on Mars.	green		Outcomes originated in FY 2004		
APG 4MEP14	Successfully demonstrate progress in searching for chemical and biological signatures of past and present life on Mars. Progress towards achieving outcomes will be validated by external review.	green		3S8 green	2S8 green	1S14 blue

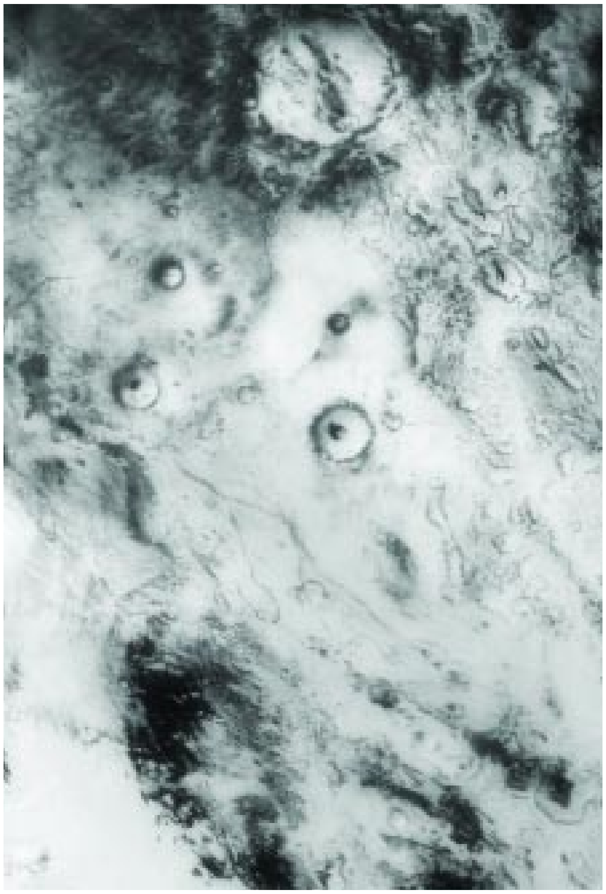
Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.5

Develop an understanding of Mars in support of future human exploration.

WHY PURSUE OBJECTIVE 5.5?

Mars is Earth's closest planetary neighbor, so of all of the Sun's planets, researchers can most easily explore Mars. NASA intends to send human missions to the Red Planet. Before a crew is sent, however, NASA is using robotic missions to identify useful resources and potential hazards. NASA Mars missions will perform a number of functions: characterize the distribution of water (both ice and liquid) from orbit and from on site analysis of local materials; analyze the space radiation environment on and around Mars; measure the Martian surface's mechanical properties; and study the composition of specific rocks and soils.



Credit: NASA JPL/Malin Space Science Systems

Figure 94: This Mars Global Surveyor image, taken with the Mars Orbiter Camera in late 2003, shows Mars' retreating seasonal southern polar cap. The bright areas are covered with frost and the dark areas are those from which the solid carbon dioxide has sublimed away. The image is illuminated by sunlight from the upper left.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.5.1 and 5.5.2 and determined that NASA successfully demonstrated progress in both Outcomes during FY 2004. In both Outcomes, the Space Science Advisory Committee recommended a "blue" rating indicating exceptional achievement (e.g., results of major importance or significant unexpected discoveries), relative to resources invested in those research focus areas.

Outcome 5.5.1: Identify and understand the hazards that the Martian environment will present to human explorers.

NASA made exceptional progress in this Outcome by using the Mars Global Surveyor to look for current and future hazards. The Mars Global Surveyor team developed the ability to collect images of the Martian surface that identify objects smaller than 1 meter. This data proved useful in identifying hazards at the Mars Exploration Rover landing sites. NASA's Mars Reconnaissance Orbiter, which will launch in 2005, will provide a more extensive data set at similar resolution. The data obtained by the Mars Reconnaissance Orbiter could be used to select future human landing sites. In addition to assuring safe landing sites, the Mars Global Surveyor's Thermal Emission

Spectrometer observations are collecting the data necessary for researchers to understand middle-atmosphere winds and atmospheric profiles (i.e, pressure and density versus altitude), which are important during entry, descent, and landing on Mars. This data will benefit the design and operation of human flight systems.

Outcome 5.5.2: Inventory and characterize Martian resources of potential benefit to human exploration of Mars.
NASA's exceptional progress in this Outcome included developing an inventory of ice concentration in Martian soils. The Mars Odyssey team developed a seasonal inventory of ice concentration in soils at high latitudes, as well as an initial analysis of hydrogen enrichment (a likely indicator of OH-bearing minerals like hydroxides and/or hydrates) in soils at mid and equatorial latitudes. These results provide a basis for identifying water-rich locations on the surface of Mars. In addition, the discovery of water ice exposed on the Martian surface indicates clearly accessible resources for future human explorers.

Performance Measures for Objective 5.5		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.5.1	Identify and understand the hazards that the Martian environment will present to human explorers.	blue		Outcomes originated in FY 2004		
APG 4MEP15	Successfully demonstrate progress in identifying and studying the hazards that the Martian environment will present to human explorers. Progress towards achieving outcomes will be validated by external review.	blue		3S8 green	2S8 blue	none
Outcome 5.5.2	Inventory and characterize Martian resources of potential benefit to human exploration of Mars.	blue		Outcomes originated in FY 2004		
APG 4MEP16	Successfully demonstrate progress in inventorying and characterizing Martian resources of potential benefit to human exploration of Mars. Progress towards achieving outcomes will be validated by external review.	blue		3S8 green	2S8 blue	none

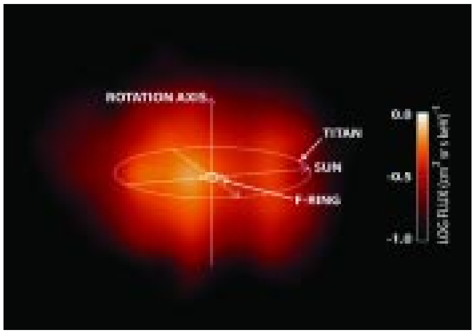
Goal 5 Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.6

Understand the changing flow of energy and matter throughout the Sun, heliosphere, and planetary environments.

WHY PURSUE OBJECTIVE 5.6?

Life on Earth prospers in a biosphere sustained by energy from the Sun. The Sun's energy output is constant when averaged over millennia, yet highly variable on an 11-year cycle and, sometimes, from second to second. The planets and moons of the solar system orbit within these inhospitable outer layers of the Sun's atmosphere. Some of these planetary bodies, like Earth, have an atmosphere and magnetic field that partially shield the surface from dangerous radiation and particles coming from the Sun and the galaxy beyond.



Credit: NASA JPL/JHU

Figure 95: Saturn's magnetosphere is seen for the first time in this image taken by the Cassini spacecraft on June 21, 2004. It is invisible to the human eye, but Cassini's Magnetospheric Imaging Instrument was able to detect the hydrogen atoms (represented in red) that escape it. The emission from these hydrogen atoms comes primarily from regions far from Saturn, well outside the planet's rings, and perhaps beyond the orbit of the largest moon, Titan.

NASA is studying the structure and dynamics of the Sun, its corona and solar wind, the origins of magnetic changes in the Sun and how these solar variations create disturbances with the Earth-Sun system. NASA is also seeking to understand how the diverse planetary magnetospheres and atmospheres respond to both internal and external influences and what this information can tell us about Earth's connection to the Sun. For example, determining how powerful flares and coronal mass ejection arriving at Earth can create powerful currents and radiation to disrupt telecommunications and navigation, threaten astronauts, damage satellites, and disable electric power grids, is a primary goal.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

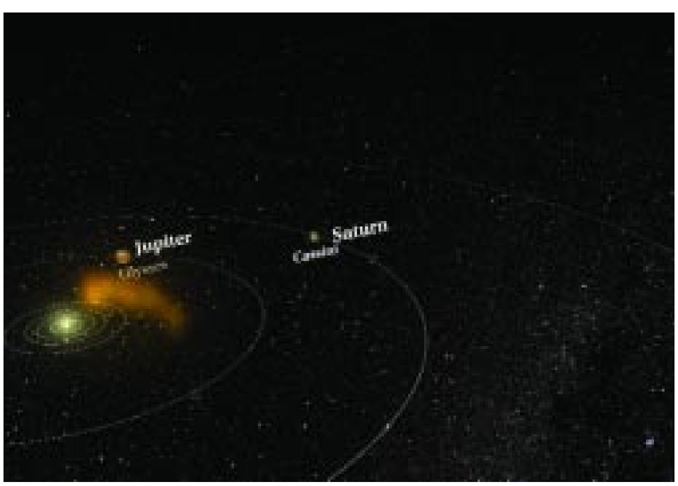
The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.6.1 through 5.6.3 and determined that NASA successfully demonstrated progress in all three Outcomes during FY 2004. In Outcome 5.6.2, the Space Science Advisory Committee recommended a "blue" rating indicating exceptional achievement (e.g., results of major importance or significant unexpected discoveries), relative to resources invested in those research focus areas.

Outcome 5.6.1: Understand the structure and dynamics of the Sun and solar wind and the origins of magnetic variability.

In FY 2004, NASA learned more about solar "pre-flares," the variable speeds of solar wind, and coronal mass ejections (huge bubbles of gas ejected from the Sun). The Ramaty High Energy Solar Spectroscopic Imager obtained the most detailed and broadest range spectra observations of the Sun's light, broken into its component colors. These observations help scientists determine what processes develop in which layers of the Sun. The Imager also discovered a sizeable population of X-ray-emitting electrons, high in the corona, about ten minutes before a solar flare. These "preflare" electrons contained as much energy as those accelerated during the main solar flare, implying that substantial energy is released in solar eruptions much earlier than previously thought. Meanwhile, NASA's Ulysses and the Transition Region and Coronal Explorer spacecraft are helping scientists understand why hotter, brighter, and more radiative regions generate slow solar wind while cooler, darker regions like coronal holes generate fast wind. Researchers working with the Solar and Heliospheric Observatory validated new computational methods for the promising technique of time-distance helioseismology (detecting magnetic flux below the Sun's surface before it erupts into sunspots, flares, and coronal mass ejections). This development is crucial for predicting the emergence of solar active regions from ground observatories. Solar and Heliospheric Observatory researchers also developed techniques for constructing three-dimensional descriptions of coronal mass ejections, the primary cause of the most violent space weather. Measuring the three-dimensional structure of coronal mass ejections is vital for understanding how the eruptions begin and how they evolve as they propagate in the solar wind.

Outcome 5.6.2: Determine the evolution of the heliosphere and its interaction with the galaxy.

In Fall 2003, a large cluster of active regions on the Sun produced a series of solar flares and coronal mass ejections that caused a series of blast waves to radiate through the solar system. NASA's fleet of satellites throughout the solar system observed for the first time the progress and timing of the blast waves as they rushed through the solar system and pushed the solar system boundary 1.5 billion miles deeper into interstellar space, expanding the volume of the Sun's corner of the galaxy by almost a third. The storms produced deadly particle radiation equal to one-half of the total emitted from the Sun in the last ten years and affected satellite operations from Earth to Mars. Meanwhile, on the outer edges of the solar system, Voyager-1, now roughly 90 times farther from the Sun than is the Earth, continues to detect dramatic changes in high-energy particles, signaling its proximity to the outer boundary of the solar wind. Voyager-1's observations reflect the ebb and flow of the edge of the solar system as it recedes and overtakes NASA spacecraft and so is revealing previously unknown dynamics of the solar system's interaction with the galaxy. NASA researchers also discovered some anomalous cosmic rays resulting from interactions with dust grains from the Kuiper Belt, a region of remnants located past Neptune, left over from the formation of the solar system. The discovery that these anomalous cosmic rays can be generated from material in the Kuiper Belt provides a path for understanding the Belt's size, composition, and processes.



Credit: NASA/Walt Feimer

Figure 96: The Sun regularly sends massive solar explosions of radiative plasma with the intensity of a billion megaton bombs hurtling through the solar system. NASA spacecraft observed such an event that began in October 2003, passed the Ulysses and Cassini spacecraft near Jupiter and Saturn in November, and reached the Voyager spacecraft at the edge of the solar system in June 2004.

Outcome 5.6.3: Understand the response of magnetospheres and atmospheres to external and internal drivers.

Activities contributing to NASA's progress included making new comparisons between planetary environments and learning more about Earth's magnetopause (the magnetic boundary between the Earth's field and the solar wind) and the atmospheres of other planets. NASA's satellites and orbiting telescopes made observations of Mars, Saturn, Jupiter, and Jupiter's moon, Io, and revealed information under a range of conditions not available on Earth. An investigation at Mars and Earth revealed that solar energy accounts for the basic variability in both Mars' and Earth's ionospheres. The Hubble Space Telescope imaged Saturn's aurora while Cassini collected radio measurements and images of the high-energy particles revealing that the magnetosphere of Saturn, like that of the Earth, is strongly affected by changes in the solar wind. This is surprisingly different from the magnetosphere of Jupiter, which appears to be internally powered. Cassini also detected plasma bubble structures at the edge of the Io torus, a giant doughnut-shaped gaseous ring around Jupiter. The discovery is helping NASA understand similar smaller scale structures called spread-F irregularities on Earth. At Jupiter, NASA's Ulysses' Jupiter Distant Encounter detected dust streams from Jupiter's magnetosphere at unexpectedly large distances and latitudes indicating that the heliospheric magnetic field is deflecting the electrically charged dust streams. Studying the behavior of dust streams and their interactions with magnetic fields is providing new insight on moon and planet formation.

Closer to Earth, five satellites, (1) the Polar; (2) the Cluster; (3) the Fast Auroral Snapshot Explorer; (4) the Imager for Magnetopause-to-Aurora Global Exploration; and (5) the Advanced Composition Explorer, continued to advance researchers' knowledge of planetary magnetopauses with new discoveries of large electric fields at the magnetopause boundary and the continuous presence of a large opening in the Earth's magnetic shield that let solar wind pour into the Earth's atmosphere. The satellites also revealed that the Earth's inner plasmasphere (part of Earth's magnetic field) rotates at a rate 10-15 percent slower than the solid Earth's rotation rate. Also, the Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics mission revealed that Earth's upper atmosphere temperatures are driven directly by the Sun. Researchers also confirmed the existence of a "natural thermostat" that regulates upper atmospheric temperatures during solar storms, cooling them to pre-storm levels in a matter of days. Without this mechanism, cooling to pre-storm levels would require seven to ten days, which is longer than the time between disturbances. Researchers also confirmed predictions that a chemical reaction between atomic hydrogen and ozone is the major source of heat near the mesopause, the uppermost region of the mesosphere that is located 50-80 kilometers above the Earth's surface.

Performance Measures for Objective 5.6		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.6.1	Understand the structure and dynamics of the Sun and solar wind and the origins of magnetic variability.	green		Outcomes originated in FY 2004		
APG 4SEC11	Successfully demonstrate progress in understanding the structure and dynamics of the Sun and solar wind and the origins of magnetic variability. Progress towards achieving outcomes will be validated by external review.	green		3S7 green	2S7 green	none
Outcome 5.6.2	Determine the evolution of the heliosphere and its interaction with the galaxy.	blue		Outcomes originated in FY 2004		
APG 4SEC12	Successfully demonstrate progress in determining the evolution of the heliosphere and its interaction with the galaxy. Progress towards achieving outcomes will be validated by external review.	blue		none	none	none
Outcome 5.6.3	Understand the response of magnetospheres and atmospheres to external and internal drivers.	green		Outcomes originated in FY 2004		
APG 4SEC13	Successfully demonstrate progress in understanding the response of magnetospheres and atmospheres to external and internal drivers. Progress towards achieving outcomes will be validated by external review.	green		none	none	none

Goal 5 Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.7

Understand the fundamental physical processes of space plasma systems.

WHY PURSUE OBJECTIVE 5.7?

The seemingly empty void between objects in the solar system is actually filled with a complex web of magnetic fields that interact and transfer energy across the heliosphere, the region of space influenced by the Sun. NASA seeks to discover how solar and planetary magnetic fields are created and evolve; how they produce heat and high-energy particles; and how to create, destroy, and reconnect magnetic fields. NASA's space plasma research focuses on understanding how and why processes that occur on very small scales generally affect large-scale global dynamics. This interaction across multiple scale lengths is important for understanding instabilities and turbulence in all space plasmas. The solar system offers the opportunity to test scientific understanding of these processes in diverse plasma environments.

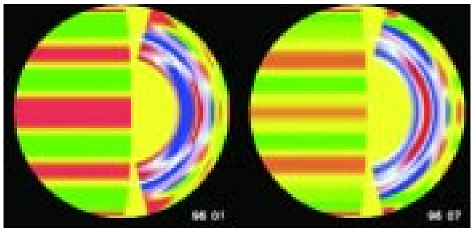


Figure 97: Currents of gas deep inside the Sun pulsate like the blood in human arteries, speeding and slackening every 16 months. Located about 135,000 miles below the solar surface, the tachocline separates the sun's two major regions of gas: the radiative zone, which includes the energy-generating core, and the convection zone near the surface. Measurements taken by the Solar and Heliospheric Observatory spacecraft indicate that the 11-year sunspot cycle originates in this area where electrically charged gases generate a magnetic field.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.7.1 and 5.7.2 and determined that NASA successfully demonstrated progress in both Outcomes during FY 2004.

Outcome 5.7.1: Discover how magnetic fields are created and evolve and how charged particles are accelerated.

NASA conducted research to understand: magnetic reconnection, particle acceleration, radio emissions called "auroral roar," and movements going on below the Sun's surface. The Cluster, Polar, Geotail, and Wind missions resolved several uncertainties associated with magnetic reconnection, a process that occurs in magnetic fields where magnetic lines of force are broken and reconnected in a different way, liberating magnetic energy into other forms such as kinetic energy, heat and light. Researchers observing the Earth's bow shock (the area where the solar wind meets the Earth's protective magnetic field, the magnetosphere) settled a long-standing debate about the sources of ion beams and the basic properties of particle acceleration at the bow shock. Shocks serve as natural particle accelerators throughout the universe and are an important source of galactic cosmic rays. Researchers also answered some long-standing questions about the source of a radio emission called "auroral roar" that can be detected in regions that experience auroras on Earth. Researchers used a High-Bandwidth Auroral Rocket to penetrate the source region and measured the detailed spectrum of the emissions. The rocket confirmed the presence of electric waves with characteristics similar to those predicted by current theories. Finally, the Solar and Heliospheric Observatory measurements of subsurface motions on the Sun revealed that the 11-year sunspot cycle originates in a very thin shell called the tachocline, a region of intense shear motion about a third of the way down into the solar interior where the magnetic field is confined and amplified. The measurements explain the occurrence of long-lived nests of solar activity and the synchronization of the Sun's northern and southern hemisphere activity cycles.

Outcome 5.7.2: Understand coupling across multiple scale lengths and its generality in plasma systems.

FY 2004 initiatives contributed to researchers' increased understanding of the effects of solar heating on the thermosphere (the uppermost thermal layer of the atmosphere) and the coupling of different effects in the solar wind. Using the Thermosphere, Ionosphere, Mesosphere, Energetics, and Dynamics instrument, NASA researchers revealed the upward movement, into the thermosphere, of waves generated by latent heating. A similar calculation for Mars demonstrated that these effects on the upper atmosphere of Mars are even greater than that on Earth. NASA also launched its first extended "horizontal-trajectory" sounding rocket flight and discovered that auroral arcs (luminous bands elongated in an east-west direction) do not drive upper atmospheric winds and play little role in thermospheric mixing. NASA researchers also revealed a new understanding of the coupling between turbulence, shear and energetic particles in the solar wind. This expands understanding of heliospheric structure, basic plasma physics, and charged particle transport theory.

Performance Measures for Objective 5.7		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.7.1	Discover how magnetic fields are created and evolve and how charged particles are accelerated.	green		Outcomes originated in FY 2004		
APG 4SEC14	Successfully demonstrate progress in discovering how magnetic fields are created and evolve and how charged particles are accelerated. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.7.2	Understand coupling across multiple scale lengths and its generality in plasma systems.	green		Outcomes originated in FY 2004		
APG 4SEC15	Successfully demonstrate progress in understanding coupling across multiple scale lengths and its generality in plasma systems. Progress towards achieving outcomes will be validated by external review.	green		none	none	none

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.8

Learn how galaxies, stars, and planetary systems form and evolve.

WHY PURSUE OBJECTIVE 5.8?

Today, the universe is a structured place, filled with giant galaxies of stars and planetary bodies. This structure emerged several hundred million years after the Big Bang from a nearly formless sea of matter and radiation. NASA is seeking to determine how this sea of formless matter organized into complex forms of matter and energetic processes that produced the first stars and galaxies, how different galactic systems of stars and gas form, and which of these systems can lead to planets and living organisms. NASA scientists are tracing the condensation of gas and dust into stars and planets and detecting planetary systems around other stars with the ultimate goal of understanding planetary systems and their evolution. NASA is learning how the life cycle of stars creates the chemical elements needed for planets and life and trying to determine if there is a region in the Milky Way that is especially suited to the development of life—a "galactic habitable zone." Current and future space observatories are capturing the birth of stars and the emergence of planets from disks of ice and dust and providing glimpses of distant objects formed when the universe was young.

Credit: NASA/JPL-Caltech/G. Melnick, Harvard-Smithsonian CfA

Figure 98: In this false-color image taken on October 23, 2003, the Spitzer Space Telescope captures a microcosm of star formation in a cloudy region called Sharpless 140, which lies in constellation Cepheus. The red bowl shape traces the outer surface of the dense dust cloud encasing young stars.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.8.1 through 5.8.4 and determined that NASA successfully demonstrated progress in all four Outcomes during FY 2004. In two of the Outcomes (5.8.1 and 5.8.4), the Space Science Advisory Committee recommended a "blue" rating indicating exceptional achievement (e.g., results of major importance or significant unexpected discoveries) relative to resources invested in those research focus areas.

Outcome 5.8.1: 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.

NASA's exceptional progress in this Outcome included observations from the Hubble Space Telescope and the Galaxy Evolution Explorer and insight into the formation of the first stars in the Universe. Using observations from the Hubble Space Telescope, researchers unveiled the deepest portrait of the visible universe ever achieved. The new portrait, called the Hubble Ultra Deep Field, revealed the first galaxies to emerge from the so-called "dark ages," the time shortly after the Big Bang when the first stars reheated the cold, dark universe. The new image should offer new insights into what types of objects reheated the universe long ago. Researchers also compared the catalogs of distant galaxies in the Hubble Ultra Deep Field and in the Great Observatories Origins Deep Survey to gain insight into the early processes that may have been responsible for some or all of the re-ionization of hydrogen in the early universe. Through this process, the first stars in the universe grouped in proto-galaxies and created small transparent regions around them. These regions increased in size until the neighboring regions merged together and cleared up the "fog" of neutral hydrogen making the universe transparent to star light as it is now). In FY 2004, the Galaxy Evolution Explorer, which will study the rate of star formation in the local universe, began full science operations and received

Credit: NASA/JPL/Caltech

Figure 99: The Galaxy Evolution Explorer (GALEX) celebrated the first anniversary of its launch on April 23, 2003, with this image of a pair of galaxies 10 million light-years away. The galaxies are M81, similar in size and brightness to the Milky Way, and M82, where stars are violently forming and expelling gas and dust out perpendicular to its disk.

some initial results. Researchers also used observations from the Wilkinson Microwave Anisotropy Probe and the Sloan Digital Sky Survey to stimulate a significant amount of theoretical work on the first stars in the universe, leading to the belief that the formation of the first stars was a prolonged process.

Outcome 5.8.2: Understand how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life.

Achievements contributing to NASA's progress included new observations from the Chandra X-Ray facility and the Galaxy Evolution Explorer. Researchers using the Chandra X-ray Observatory discovered rich deposits of neon, magnesium, and silicon in a pair of colliding galaxies known as The Antennae. According to theory, when the clouds in which these elements are present cool, an exceptionally high number of stars with planets should form. The amount of enrichment of elements in The Antennae is high due to a very high rate of supernova explosions in these colliding galaxies. When galaxies collide, direct hits between stars are extremely rare, but collisions between huge gas clouds in the galaxies can trigger a stellar formation burst. The most massive of these stars race through their evolution in a few million years and explode as supernovas. Heavy elements manufactured inside these stars are blown away by the explosions and enrich the surrounding gas for thousands of light years. A number of studies indicate that clouds enriched in heavy elements are more likely to form stars with planetary systems, so in the future, an unusually high number of planets may form in The Antennae. Observations from the Galaxy Evolution Explorer also revealed striking images of star formation. (The Galaxy Evolution Explorer large-format detectors were developed under the sub-orbital program over many years and are providing a spectacular return on the original investment.)

Outcome 5.8.3: Learn how gas and dust become stars and planets.

NASA researchers used the Far Ultraviolet Spectroscopic Explorer and the Hubble Space Telescope to observe HR 4796A, a nearby 8 million year old main-sequence star surrounded by a dusty disk that may form planets in that system. Researchers looked for significant amounts of elements heavier than hydrogen, but failed to detect any of these species. These measurements suggest that this stellar system possesses very little molecular gas and may not be able to form a planet as big as Jupiter. The Spitzer Space Telescope successfully completed in-orbit checkout and began science operations. Since it began operations, Spitzer has discovered hundreds of protostars in high mass star forming regions. These observations will provide quantitative information on the rapid and rare formation process of stars heavier than the Sun. Delays with the Stratospheric Observatory for Infrared Astronomy slowed its deployment. When deployed, the observatory has the potential to have a major impact on scientists' understanding of star formation.

Outcome 5.8.4: Observe planetary systems around other stars and compare their architectures and evolution with our own.

NASA-funded researchers discovered the most distant object orbiting the Sun. The object is a mysterious planet-like body three times farther from Earth than Pluto. The object, called "Sedna" for the Inuit goddess of the ocean, is 8 billion miles away in the farthest reaches of the solar system. This is likely the first detection of the long-hypothesized Oort cloud, a repository of small icy bodies on the fringe of the solar system that supplies the comets that streak by Earth. Other notable features of Sedna include its size and reddish color. After Mars, it is the second reddest object in the solar system. It is estimated Sedna is approximately three-fourths the size of Pluto. Sedna is likely the largest object found in the solar system since Pluto was discovered in 1930. Sedna is extremely far from the Sun, in the coldest known region of the solar system, where temperatures never rise above minus 400 degrees Fahrenheit. In another finding, the Spitzer Space Telescope surveyed a group of young stars and found intriguing evidence that one of them may have the youngest planet detected. The observatory found a clearing in the disk around the star CoKu Tau 4. This might indicate that an orbiting planet swept away the disk material. The new findings reveal the structure of the gap more clearly than ever. CoKu Tau 4 is only about one million years old; the possible new planet would be even younger. In comparison, the Earth is approximately 4.5 billion years old.

Performance Measures for Objective 5.8		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.8.1	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.	blue		Outcomes originated in FY 2004		
APG 4ASO9	Successfully demonstrate progress in learning 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. Progress towards achieving outcomes will be validated by external review.	blue		3S3 green	2S3 green	none
Outcome 5.8.2	Understand how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life.	green		Outcomes originated in FY 2004		
APG 4ASO10	Successfully demonstrate progress in understanding how different galactic ecosystems of stars and gas formed and which ones might support the existence of planets and life. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.8.3	Learn how gas and dust become stars and planets.	green		Outcomes originated in FY 2004		
APG 4ASO11	Successfully demonstrate progress in learning how gas and dust become stars and planets. Progress towards achieving outcomes will be validated by external review.	green		3S3 green	2S3 green	none
Outcome 5.8.4	Observe planetary systems around other stars and compare their architectures and evolution with our own.	blue		Outcomes originated in FY 2004		
APG 4ASO12	Successfully demonstrate progress in observing planetary systems around other stars and comparing their architectures and evolution with our own. Progress towards achieving outcomes will be validated by external review.	blue		3S4 blue	2S4 green	none

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.9

Understand the diversity of worlds beyond our solar system and search for those that might harbor life.

WHY PURSUE OBJECTIVE 5.9?

After centuries of speculation, scientists now know that there are planets orbiting other stars. The extrasolar planets discovered so far seem to be gas giants like Jupiter. Earth-like worlds also may orbit other stars, but until now, the resources used to search for planets lacked the precision needed to detect a world as small as Earth.

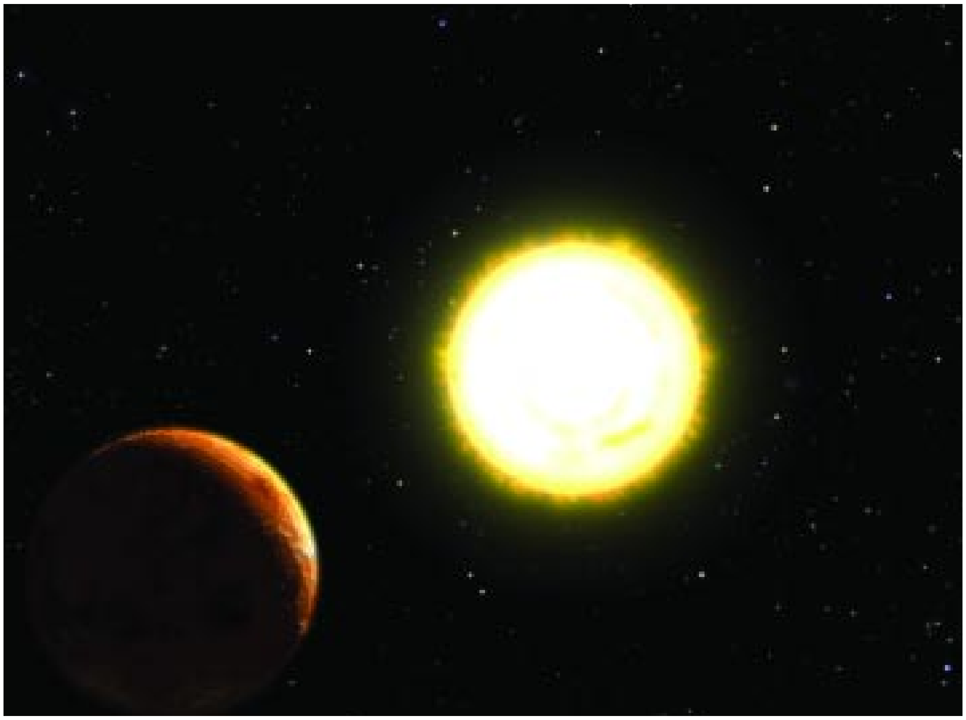


Figure 100: This artist's concept shows a Neptune-sized planet—one of the smallest extrasolar planets found to date—orbiting 55 Cancri, a star in the constellation Cancer. The planet was one of two newly found Neptune-sized planets (the other circles M dwarf star Gliese 436) announced on August 31, 2004, by Paul Butler (Carnegie Institute of Washington) and Geoffrey Marcy (University of California, Berkeley), a planet-finding team funded by NASA and the National Science Foundation.

NASA is moving toward finding extrasolar, Earth-like planets and, ultimately, life beyond this solar system. Along the way, NASA is discovering the nature and properties of giant planets orbiting other stars and which of them might be hospitable to life. Detailed studies of giant planets will tell scientists much about the formation and history of planetary systems.

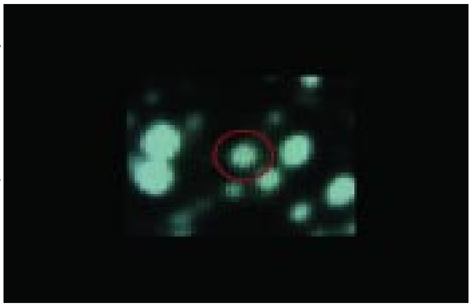
NASA's space observatories allow scientists to analyze atmospheric properties of these distant giants, even if they cannot observe the planet directly. Once NASA has found terrestrial planets orbiting nearby stars, the Agency can tackle the ambitious tasks of determining which planets have conditions suitable for life and which, if any, show actual signs of past or present life. Scientists also are developing ways to identify "biosignatures," identifiable spectral features in a planet's reflected light that can reveal past or present life on a planet.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.9.1 through 5.9.4 and determined that NASA successfully demonstrated progress in all four Outcomes during FY 2004. In Outcome 5.9.4, the Space Science Advisory Committee recommended a "blue" rating indicating exceptional achievement (e.g., results of major importance or significant unexpected discoveries) relative to resources invested in those research focus areas.

Outcome 5.9.1: Characterize the giant planets orbiting other stars.

NASA astronomers created computer models of planets orbiting stars that match the data from two known systems (HD209458b and OGLE-TR-56b). These models demonstrate that astronomers now possess a good understanding of the relationships between the characteristics observed in extrasolar planets and the stars they orbit. NASA-funded theoretical work also produced new spectra and structural models of OGLE-TR-56b which is larger than Jupiter, but extremely close to its parent star. These models will help NASA understand the limits and characteristics of planets exposed to such intense radiation.



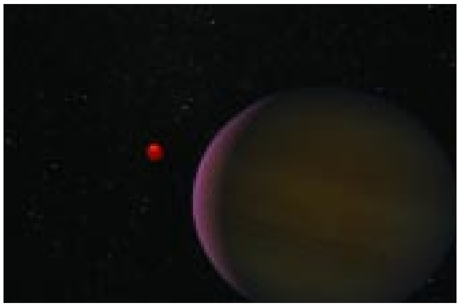


Figure 101: In April 2004, astronomers for the first time found a planet circling a star outside the solar system using gravitational microlensing, shown in this artist's concept on the right. The picture on the left was taken at Warsaw telescope at Las Campanas Observatory, Chile. Although this planet is one and a half times larger than Jupiter, astronomers believe that the importance of gravitational microlensing is its ability to find small-mass planets similar in size to Earth.

Outcome 5.9.2: Find out how common Earth-like planets are and see if any might be habitable.

For the first time, researchers discovered an extra solar planet using gravitational microlensing. In gravitational microlensing, a star or planet acts as a cosmic lens to magnify and brighten a more distant star lined up behind it. The gravitational field of the foreground star bends and focuses light, like a glass lens bending and focusing starlight in a telescope. Albert Einstein predicted this effect in his theory of general relativity and confirmed it with the Sun. Two international research teams cooperated to make the discovery: Microlensing Observations in Astrophysics and the Optical Gravitational Lensing Experiment (funded by NASA and the National Science Foundation). The newly discovered star-planet system is 17,000 light years away, in the constellation Sagittarius. The planet, orbiting a red dwarf parent star, is most likely one-and-a-half times bigger than Jupiter. The planet and star are three times farther apart than Earth and the Sun.

Outcome 5.9.3: Trace the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life.

Spitzer Space Telescope observations of young stars in the Taurus cloud revealed significant amounts of icy organic materials sprinkled throughout several "planetary construction zones" or dusty planet-forming discs that circle infant stars. These materials, icy dust particles coated with water, methanol, and carbon dioxide, may help explain the origin of icy planetoids like comets. Previous studies identified similar organic materials in space, but this is the first time they were seen clearly in the dust making up planet forming discs. NASA researchers also made progress in tracing the link between ice processes and the organic molecules in meteorites by theorizing that some of the interesting organic compounds found in meteorites may have formed in presolar ice and were not a product of water existing on the original source of the meteorite (i.e., planet, comet, asteroid). Scientists previously demonstrated that ultraviolet radiation can break down chemicals in ice left over from the formation of the Solar System, so called presolar ice, producing amino acids, the building blocks of life. Researchers also found proof of organic compounds in the Murchison meteorite that fell in Murchison, Victoria, Australia in 1969. The meteorite contained a wide variety of organic compounds and showed that many organic molecules can be formed in space. This discovery raised the possibility that such extraterrestrial material might have played a role in the origin of life.

Outcome 5.9.4: Develop the tools and techniques to search for life on planets beyond our solar system.

Activities contributing to NASA's exceptional progress in this Outcome included developing methods for imaging Earth-like extra-solar planets and detecting the biological signs of life in extra solar planetary atmospheres and interstellar space. NASA researchers developed and tested techniques like star-light suppression for observing faint planets near bright stars and theoretical advances in coronagraph design. (A coronagraph is a telescope that can see things very close to a star, like the Sun). These advances suggest that NASA now has the technology needed to directly image Earth-like planets around nearby stars. NASA researchers also used laboratory measurements of organic molecules found in interstellar space to identify promising potential astronomical observations for detecting biological precursor molecules in interstellar space in this Galaxy. NASA also continues to study and model Earth-like planetary atmospheres around stars of different temperatures to assess the detectability of global signs of life.

Performance Measures for Objective 5.9		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.9.1	Characterize the giant planets orbiting other stars.	green		Outcomes originated in FY 2004		
APG 4ASO13	Successfully demonstrate progress in characterizing the giant planets orbiting other stars. Progress towards achieving outcomes will be validated by external review.	green		3S4 blue	2S4 green	none
Outcome 5.9.2	Find out how common Earth-like planets are and see if any might be habitable.	green		Outcomes originated in FY 2004		
APG 4ASO14	Successfully demonstrate progress in finding out how common Earth-like planets are and seeing if any might be habitable. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.9.3	Trace the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life.	green		Outcomes originated in FY 2004		
APG 4ASO15	Successfully demonstrate progress in tracing the chemical pathways by which simple molecules and dust evolve into the organic molecules important for life. Progress towards achieving outcomes will be validated by external review.	green		3S6 green	2S6 green	none
Outcome 5.9.4	Develop the tools and techniques to search for life on planets beyond our solar system.	blue		Outcomes originated in FY 2004		
APG 4ASO16	Successfully demonstrate progress in developing the tools and techniques to search for life on planets beyond our solar system. Progress towards achieving outcomes will be validated by external review.	blue		3S4 blue	2S4 green	none
				3S6 green	2S6 green	none

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.10

Discover what powered the Big Bang and the nature of the mysterious dark energy that is pulling the Universe apart.

WHY PURSUE OBJECTIVE 5.10?

Although Einstein's General Theory of Relativity predicted the expansion of the universe, it did not explain the causes of this expansion. Today NASA has strong evidence that within the first infintesimal fraction of a second of its existence, the universe "inflated" its size enormously, producing a spacious arena for stars, galaxies, and the evolution of life. The underlying force behind this inflationary epoch is still not known, and is one of the most important questions related to the history of the universe. By one second after the beginning of time, with its inflation completed, the universe was again expanding in accord with Einstein, gradually slowing its expansion rate due to the attractive force of gravity generated by the universe's mass. Very recently, however, NASA has learned that some billions of years ago the universe started to accelerate its expansion, as though some form of anti-gravity were at work. Indeed, Einstein's theory allowed for the existence of a "dark energy" that uniformly pervades all of space which has this effect, and such dark energy is now known to exist. Its orgin, however, is completely unknown. Solving the mystery of dark energy is considered to be the most important task not only of cosmology, but also of particle physics.

Credit: Optical: NOAO/Kitt Peak/J.Uson, D.Dale; X-ray: NASA/CXC/IoA;S.Allen, et al.

Figure 102: Astronomers have detected and probed dark energy by applying a powerful, new method that uses images of galaxy clusters made by NASA's Chandra X-ray Observatory, like this composite image of galaxy cluster Abell 2029 from May 2004. The results trace the transition of the expansion of the universe from a decelerating to an accelerating phase several billion years ago, and give intriguing clues about the nature of dark energy and the fate of the universe.

The growth, shape, size, and destiny of the universe are determined by a tug-of-war among visible matter, dark matter, and dark energy. Dark matter, which constitutes 23 percent of the universe, is an as-yet unidentified form of matter. The only part of the universe humans really understand is visible matter (atoms), just four percent of the universe! NASA's current and future missions will help to increase understanding of the other 96 percent, by providing insights into the nature of dark matter and dark energy and their effects on the formation of clusters of galaxies, and on the ultimate destiny of the universe. NASA missions will also probe to the beginning of time, to view directly the inflation that made the universe as big as it is.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.10.1 through 5.10.3 and determined that NASA successfully demonstrated progress in all three Outcomes during FY 2004. In Outcome 5.10.3, the Space Science Advisory Committee recommended a "blue" rating indicating exceptional achievement (e.g., results of major importance or significant unexpected discoveries) relative to resources invested in those research focus areas.

Outcome 5.10.1: Search for gravitational waves from the earliest moments of the Big Bang.

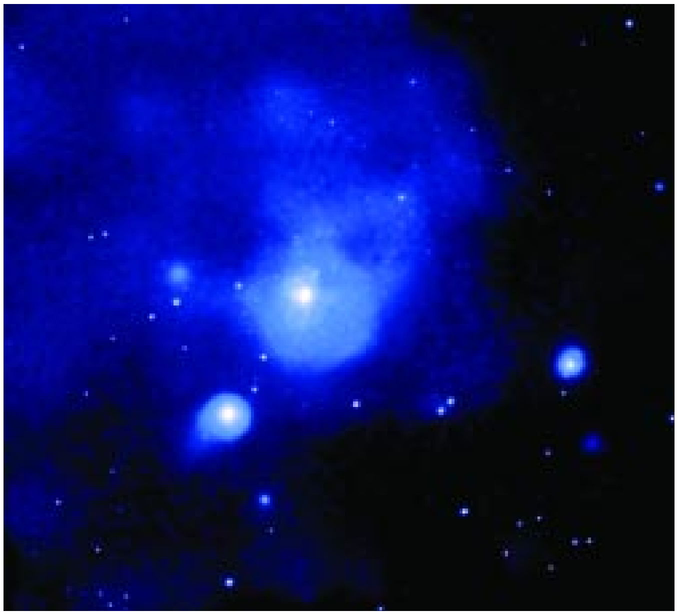
This year, NASA got a better look at the cosmic microwave background (a telltale remnant of the early universe), working toward a closer look at the Big Bang and establishing a multi-agency task force on cosmic microwave background research. The first two years of data from the Wilkinson Microwave Anisotropy Probe provided the first look at the full-sky polarization of the cosmic microwave background. NASA also selected a concept study for the Big Bang Observer, the goal of which is to observe directly the primordial gravitational waves that were produced at the beginning of time. Of all waves and particles known to physics, gravitational waves interact the least. So, they carry information undisturbed from the earliest moments of the universe, helping to elucidate its origin. NASA also worked with the National Science Foundation and the Department of Energy to establish an Interagency Task Force for Cosmic Microwave Background Research. The task force will provide a roadmap for the technology development required for a space mission to obtain the definitive polarization map of the cosmic microwave background.

Outcome 5.10.2: Determine the size, shape, and matter-energy content of the Universe.

NASA successfully demonstrated progress in this Outcome by continuing operation of the Wilkinson Microwave Anisotropy Probe mission at the L2 Lagrange point (a point in space where the gravitational pull of the Earth and the Sun cancel each other out creating a relatively stable home for a spacecraft). Also, significant progress was made by the Wilkinson Microwave Anisotropy Probe team toward constructing the first full-sky map of the cosmic microwave background polarization. This tremendous achievement is expected to reach completion in early FY 2005. The map will improve our determination of the cosmological parameters that dictate the state of the universe and improve our understanding of the very early history of the universe.

Outcome 5.10.3: Measure the cosmic evolution of dark energy.

Using the Hubble Space Telescope, NASA researchers discovered 42 new supernovae, including six of the seven most distant known. (Supernovae are caused when super-massive stars collapse, producing some of the most energetic explosions in the universe). Using these supernovae as "standard candles," of known luminosity, researchers confirmed the existence of dark energy and placed new limits on dark energy's time variability. Using Chandra, researchers also studied 26 distant galaxy clusters between one and eight billion years away tracing back in time to when the universe began to accelerate. Those findings corroborated the existence of dark energy. NASA and the Department of Energy began the formation of a science definition team for the NASA/Department of Energy Joint Dark Energy Mission. The science definition team will help assure the optimum scientific return from a dark energy space mission. Also, NASA researchers used the XMM Newton satellite to survey distant clusters of galaxies and found puzzling differences between today's clusters of galaxies and those present in the Universe about seven billion years ago. The results show that clusters of galaxies in the distant Universe seem to produce more X-rays than today, indicating that these clusters have changed their appearance with time. This finding will have an impact on using clusters as a probe of the existence of dark energy.



Credit: NASA/CXC/Comubia Univ./C. Scharf et al.

Figure 103: A Chandra X-Ray Observatory mosaic of images of the Fornax galaxy cluster reveals that the vast cloud of ten-million-degree Celsius gas surrounding the cluster core has a swept-back cometary shape that extends for more than half a million light years. Fornax is just one of the many clusters that Chandra imaged this fiscal year.

Performance Measures for Objective 5.10		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.10.1	Search for gravitational waves from the earliest moments of the Big Bang.	green		Outcomes originated in FY 2004		
APG 4SEU9	Successfully demonstrate progress in search for gravitational waves from the earliest moments of the Big Bang. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.10.2	Determine the size, shape, and matter-energy content of the universe.	green		Outcomes originated in FY 2004		
APG 4SEU10	Successfully demonstrate progress in determining the size, shape, and matter-energy content of the universe. Progress towards achieving outcomes will be validated by external review.	green		3S1 blue	2S1 green	none
Outcome 5.10.3	Measure the cosmic evolution of dark energy.	blue		Outcomes originated in FY 2004		
APG 4SEU11	Successfully demonstrate progress in measuring the cosmic evolution of the dark energy, which controls the destiny of the universe. Progress towards achieving outcomes will be validated by external review.	blue		none	none	none

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.11

Learn what happens to space, time, and matter at the edge of a black hole.

WHY PURSUE OBJECTIVE 5.11?

The greatest extremes of gravity in the universe today exist at the edges of black holes. Matter captured by their strong gravity falls inward, accelerating to speeds close to that of light. This infalling gas, including gas from stars shredded by the intense gravity fields, heats up dramatically and produces large quantities of X-ray radiation near the edge of a black hole. Beyond the edge, time comes to a standstill, and matter disappears from view forever.

Credit: Chandra image: NASA/CXC/A.Zezas et al.; Optical: Palomar Obs. DSS

Figure 104: The Chandra X-ray Observatory image (left, released on December 8, 2003) of the elliptical galaxy NGC 4261 reveals dozens of black holes and neutron stars strung out across tens of thousands of light years like beads on a necklace. The spectacular structure, which is not apparent from the optical image of the galaxy on the right, is thought to be the remains of a collision between galaxies a few billion years ago. According to this interpretation, a smaller galaxy was captured and pulled apart by the gravitational tidal forces of NGC 4261. As the doomed galaxy fell into the larger galaxy, large streams of gas were pulled out into long tidal tails. Shock waves in these tidal tails triggered the formation of many massive stars. Over the course of a few million years, these stars evolved into neutron stars or black holes.

By measuring the X-rays at a black hole's edge, scientists can observe the slowing of time near the surface, as Einstein predicted, and investigate how infalling matter releases energy there. Scientists also can observe the evolution of black holes and quasars to determine their role in the evolution of their host galaxies.

Closer to home, NASA is using Gravity Probe B, launched in April 2004, to test Einstein's theory of space and time. Gravity Probe-B is a polar-orbiting satellite that will measure the remarkable effects caused by the distortion of space–time created by the spinning mass of Earth as predicted by Einstein's General Theory of Relativity.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.11.1 through 5.11.3 and determined that NASA successfully demonstrated progress in all three Outcomes during FY 2004.

Outcome 5.11.1: Determine how black holes are formed, where they are, and how they evolve.

NASA made progress in this Outcome by coordinating observations from three different space telescopes to get a better look at black holes, understanding a new class of black holes, and determining how super-massive black holes are produced. As part of the Great Observatories Origins Deep Survey, NASA researchers used observations from the Spitzer Space Telescope, the Hubble Space Telescope, and the Chandra X-ray Observatory to demonstrate that 100 percent of approximately 200 X-ray sources believed to be super-massive black holes are located within young galaxies. Spitzer showed that previously unseen galaxies actually exist outside of Hubble's wavelength range. This result demonstrates the value of coordinating observations from NASA's three Great Observatories.

NASA researchers used Chandra to detect an "intermediate mass" black hole, i.e., one with approximately 1000 solar masses in a stellar cluster, in the starburst galaxy M82. Researchers used this stellar cluster as a model to calculate how the region produced this type of black hole, and these calculations explain the processes and conditions necessary to produce this new class of intermediate black holes. Meanwhile, recent calculations funded by the Astrophysics Theory Program suggest that super-massive black holes are produced by accretion of gas and not by mergers of smaller-mass black holes. When black holes merge, their final decay is fueled by energy loss due to gravitational radiation that also creates a momentum kick. In the earlier universe, galaxies were smaller, so black hole mergers likely ejected the black holes from their parent galaxies. Estimates of this kick led to this intriguing conclusion that might well be confirmed by future observations of off-center black holes that have recently received such a kick.

Outcome 5.11.2: Test Einstein's theory of gravity and map space-time near event horizons of black holes.
NASA continued testing Einstein's theory of gravity and mapping space-time near event horizons of black holes by launching Gravity Probe B, confirming Einstein's principle of the constant speed of light, and observing a spinning black hole. NASA successfully launched Gravity Probe B on April 20, 2004. Over the next year, the probe will test two predictions of Einstein's General Theory of Relativity to unprecedented precision. NASA scientists also confirmed that Albert Einstein's principle of the constancy of the speed of light (i.e., the speed of light is constant, even at extremely high energies) holds up under extremely tight scrutiny. This new research rules out some current theories predicting extra dimensions and a "frothy" fabric of space. Researchers also used Chandra and XMM-Newton to study two stellar black holes, Cygnus X-1 and XTE J1650-500. The X-ray observations revealed that the latter black hole has a high spin rate. The presence of a lower tail implies X-ray origin at 20 km from the black hole horizon, compared to a minimum X-ray origin of 100 km from the horizon of the Cygnus X-1 black hole. This demonstrates that the geometry of a spinning black hole allows atoms to orbit closer to the black hole than for a non-spinning black hole.


Credit: Stanford University

Figure 105: The Gravity Probe B spacecraft launches from Vandenberg Air Force Base on April 20, 2004.

Outcome 5.11.3: Observe stars and other material plunging into black holes.
NASA researchers used X-ray data from XMM-Newton and Chandra to provide direct evidence of the catastrophic destruction of a star that wandered too close to a super-massive black hole. The observations confirmed that a powerful X-ray outburst had occurred in the center of the galaxy RX J1242-11, which appears normal in a ground-based optical image. This X-ray outburst, one of the most powerful ever detected in a galaxy, was caused when gas from the disrupted star was heated to multi-million degree temperatures as it fell toward the black hole.

Performance Measures for Objective 5.11		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.11.1	Determine how black holes are formed, where they are, and how they evolve.	green		Outcomes originated in FY 2004		
APG 4SEU12	Successfully demonstrate progress in determining how black holes are formed, where they are, and how they evolve. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.11.2	Test Einstein's theory of gravity and map space-time near event horizons of black holes.	green		Outcomes originated in FY 2004		
APG 4SEU13	Successfully demonstrate progress in testing Einstein's theory of gravity and mapping space-time near event horizons of black holes. Progress towards achieving outcomes will be validated by external review.	green		3S2 green	2S2 green	none
Outcome 5.11.3	Observe stars and other material plunging into black holes.	green		Outcomes originated in FY 2004		
APG 4SEU14	Successfully demonstrate progress in observing stars and other material plunging into black holes. Progress towards achieving outcomes will be validated by external review.	green		none	none	none

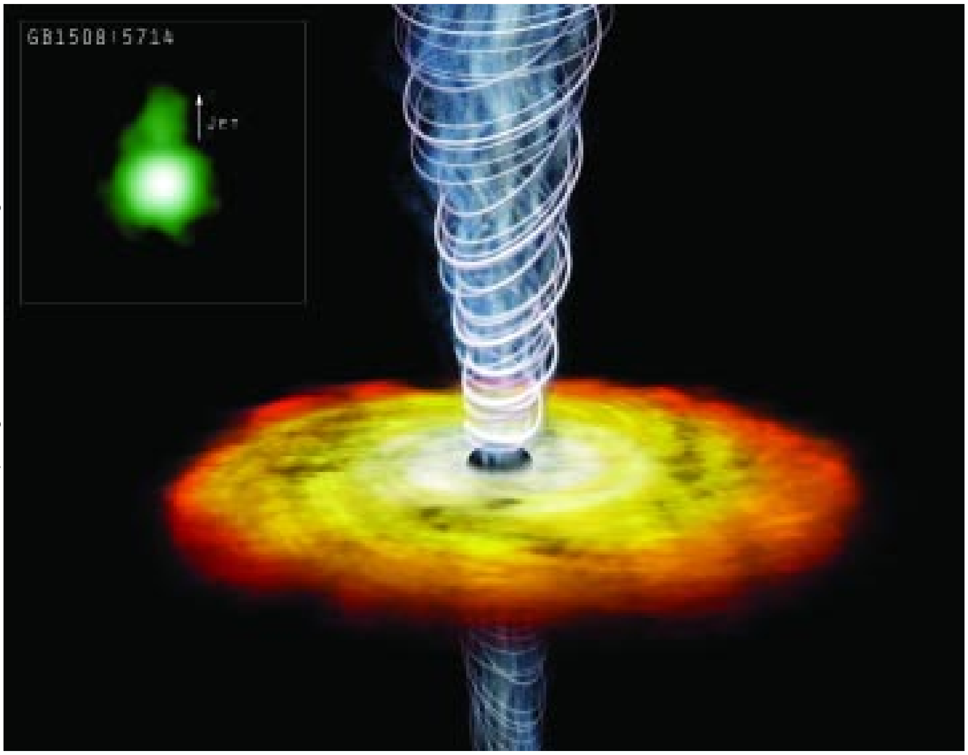
Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.12

Understand the development of structure and the cycles of matter and energy in the evolving Universe.

WHY PURSUE OBJECTIVE 5.12?

The universe is governed by cycles of matter and energy. Even as the universe expands, pockets of atomic matter and dark matter collapse by the force of gravity to form galaxies and clusters of galaxies. Dense clouds of gas within the galaxies collapse to form stars, and in the star centers, all elements heavier than hydrogen and helium are produced. When stars die, they eject some of these freshly produced, heavier elements into space forming galactic clouds of gas and dust in which future generations of stars are born, beginning another cycle of matter.



Credit: Illustration: CXC/M.Weiss; X-ray image: NASA/CXC/SAO/A.Siemiginowska et al.

Figure 106: This drawing of a Chandra X-ray Observatory image of the quasar GB1508+5714 reveals a jet of high-energy particles that extends more than 100,000 light years from the supermassive black hole powering the quasar. At a distance of 12 billion light years from Earth, this is the most distant jet ever detected. The discovery of this jet is especially significant because it provides astronomers with a way to measure the intensity of the cosmic background radiation about one billion years after the Big Bang. The jet's brightness implies that enormous amounts of energy were deposited in the outer regions of the host galaxy of the quasar at a very early stage. This energy input could have had a profound effect on the evolution of the galaxy by triggering the formation of stars, or inhibiting the accretion of matter from intergalactic space.

The luminous energy of stars comes from thermonuclear fusion: hydrogen and helium gas are burned, leaving as "ash" the heavier elements. When a star's fuel is consumed, its life ends, releasing vast quantities of energy. This energy strongly affects the environment of nearby stars and is believed to be responsible for cosmic rays, atomic particles moving at nearly the speed of light that constantly bombard Earth.

NASA is studying the cycles of matter and energy and how they created the conditions that spawned life. To understand how matter and energy are exchanged between stars and the interstellar medium, NASA is studying winds, jets, and explosive events. To understand the formation of galaxies, NASA is mapping the "invisible" universe of dark matter that helped nucleate these structures, observing the gas expelled during the birth of galaxies, and witnessing the birth of the first black holes and their effect on the formation of galaxies.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

The Space Science Advisory Committee, an external advisory board, reviewed the progress of Outcomes 5.12.1 through 5.12.3 and determined that NASA successfully demonstrated progress in all three Outcomes during FY 2004.

Outcome 5.12.1: 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.

NASA researchers, using Chandra, discovered rich abundances of neon, magnesium, and silicon in the Antennae, a pair of colliding galaxies. The collision of gas clouds in these galaxies resulted in a high rate of massive star formation and supernovae and heavy element enrichment from the ejection. Researchers now know this likely means that there will be a much higher density of planets in next-generation stellar systems, increasing the probability of formation of life in the region of activity.

The Galaxy Evolution Explorer completed the first year of its first extra-galactic, ultraviolet, all-sky survey. During its 29-month mission, the Galaxy Evolution Explorer will produce the first comprehensive map of a universe of galaxies under construction.

The Hubble Space Telescope took a one-million-second long exposure that may have revealed the first galaxies to emerge from the "dark ages," the period before stars started to form, about 13 billion years ago.

Outcome 5.12.2: Explore the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays.

NASA made progress toward this Outcome thanks to observations from the Roentgen X-ray Timing Explorer, XMM-Newton, and the Chandra X-ray observatory. Researchers using the Roentgen X-ray Timing Explorer observed a "superburst" on a neutron star that is providing valuable new clues about the innermost region of the hot accretion disk surrounding the neutron star. This is the first time that a disk near the innermost stable orbit has been seen changing its structure in real time in response to irradiation from neutron star bursts. The XMM-Newton observed in X-rays a spectacular set of expanding rings, energized by a powerful gamma-ray burst that took place in December 2003. Due to the effects of special relativity, these rings appeared to expand at a speed 1000 times greater that that of light. This fascinating event is called an "echo," and it had not been seen previously in X-rays.

Chandra observed the presence of large amounts of iron and nickel in a jet-like structure associated with the supernova remnant W49B. This suggests that the massive original star did not end its life as a normal core-collapse supernova. Instead, it is possible that the star ended as a gamma-ray burst, spewing its iron nuclei out through its jets. Images from the Palomar Observatory showed that the explosion took place in a dense molecule cloud implying a short lifetime and a large mass since the star exploded so close to where it was formed. This data is consistent with the "collapsar" model of gamma-ray bursts; if confirmed, this would be the first galactic gamma-ray burst remnant detected. The presence of a gamma-ray burst within this galaxy, coupled with the young age of the supernova remnant, could help pinpoint the rate of gamma-ray bursts.

Outcome 5.12.3: Discover how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies.

Observations from the Hubble Space Telescope, the Chandra X-ray Observatory, and XMM-Newton helped researchers determine that the galaxy cluster RCDS1252.9-292 was fully formed more than 8 billion years ago and has a mass at least 300 trillion times that of the Sun. At a distance of 8.6 billion light years, it is the most massive cluster ever observed at such an early stage in the evolution of the universe. Even though the cluster appears as it did only five billion years after the Big Bang, it has an abundance of elements similar to that of clusters observed in more recent epochs. The cluster gas must have been enriched by heavy elements synthesized in stars and ultimately ejected from the galaxies. The observations of RDCS1252 are consistent with the theory that massive stars produced most of these heavy elements more than 11 billion years ago.

Observations made with Chandra also may explain why so little cool gas is found within galaxy clusters. Chandra captured sound waves generated by a super-massive black hole in the Perseus galaxy cluster. Cooling by x-ray emission of the hot gas within galaxy clusters should result in substantial star formation, but this was not seen. In fact, the lack of star formation implies the presence of a heating mechanism, a possibility unknown until now. Researchers now believe that the presence of "black hole acoustics" likely supplies this energy and transports the equivalent energy of 100 million supernovae over distances of hundreds of thousands of light years.

Researchers using XMM-Newton observations of two quasars (PDS 456 and PG 1211+143) revealed that the presence of high velocity ionized outflows suggests that quasars may be injecting very large energies into the interstellar or intergalactic medium. The Chandra team also took long-exposure images of the giant elliptical galaxy M87 that revealed repetitive outbursts from the vicinity of the super-massive black hole. Features detected include jets, magnetized bubbles formed by their collision with surrounding gas, and sound waves emanating from the bubbles. The episodic outbursts are explained as a self-regulated, cyclic system: Cool gas flows into the vicinity of the black hole, creating activity that heats the surrounding gas. This inhibits the gas inflow, shutting down the black hole activity.

Performance Measures for Objective 5.12		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.12.1	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		Outcomes originated in FY 2004		
APG 4SEU15	Successfully demonstrate progress in determining how, where, and when the chemical elements were made, and tracing the flows of energy and magnetic fields that exchange them between stars, dust, and gas. Progress towards achieving outcomes will be validated by external review.	green		none	none	none
Outcome 5.12.2	Explore the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays.	green		Outcomes originated in FY 2004		
APG 4SEU16	Successfully demonstrate progress in exploring the behavior of matter in extreme astrophysical environments, including disks, cosmic jets, and the sources of gamma-ray bursts and cosmic rays. Progress towards achieving outcomes will be validated by external review.	green		3S2 green	2S2 green	none
Outcome 5.12.3	Discover how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies.	green		Outcomes originated in FY 2004		
APG 4SEU17	Successfully demonstrate progress in discovering how the interplay of baryons, dark matter, and gravity shapes galaxies and systems of galaxies. Progress towards achieving outcomes will be validated by external review.	green		3S1 blue	2S1 green	none

Goal 5
Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.

OBJECTIVE 5.13

Through robotic and human lunar missions, demonstrate capabilities, including use of lunar and other space resources, for safe, affordable, effective and sustainable human-robotic solar system exploration.

WHY PURSUE OBJECTIVE 5.13?

On December 13, 1972, Apollo 17 astronaut Eugene Cernan concluded the last human activities on the Moon with the statement, "I believe history will record that America's challenge of today has forged man's destiny of tomorrow." The next morning, the lander left the lunar surface to rejoin the orbiting command module and return home. More than 20 years later, in 2004, NASA announced that the Agency would meet that destiny and return humans to the Moon.

Figure 107: The Lunar Prospector, shown in an artist's concept, was NASA's last lunar mission. Launched in January 1998, this robotic mission mapped the surface composition of the Moon and searched for resources, such as the significant amounts of water ice it found at the lunar poles. With The Vision for Space Exploration, NASA announced its goal of returning both automated spacecraft and humans to the Moon.

Built on testbed activities aboard the International Space Station, NASA is developing technologies that will make advanced lunar exploration possible. The next phase of lunar exploration will involve a series of robotic missions, both orbiters and landers, to confirm and map lunar resources in detail. NASA also is planning missions to demonstrate new technological capabilities including robotic networks, reusable planetary landing and launch systems, prepositioned propellants that can serve as refueling depots, and resource extraction. The final phase will be to return human explorers to the Moon where they will demonstrate human exploration capabilities—resource utilization, habitation and life support, and planetary mobility—within relatively safe reach of Earth. These missions will be humankind's first steps toward exploring Mars and destinations beyond.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

In January 2004, NASA embraced the President's goal of returning humans to the Moon as a stepping-stone to human exploration of Mars and beyond. NASA is in the process of crafting a lunar program. Therefore, the Outcomes in this objective reflect NASA's future plans. In addition, since NASA's lunar program plan is in its infancy, the achievements under Outcome 5.13.1 also apply to Outcomes 5.13.2 through 5.13.4.

Outcome 5.13.1: Develop capability to conduct robotic lunar test bed missions by 2008 and human lunar missions as early as 2015 but no later than 2020 that can demonstrate exploration systems and architectural approaches, including use of lunar resources, to enable human-robotic exploration across the solar system.

To support near-term robotic missions to the Moon and future human exploration of the Moon and Mars, NASA established the Robotic Lunar Exploration Program Office under the leadership of a Director and a Lead Scientist, within the Solar System Exploration Division of NASA's Science Mission Directorate. In addition, the Science Mission Directorate assigned responsibility for implementation of the robotic lunar exploration program to the Goddard Space Flight Center under the guidance of a Lunar Program Manager.

The first robotic mission to prepare for future human exploration is the 2008 Lunar Reconnaissance Orbiter mission. The Orbiter will conduct investigations from lunar orbit that will be targeted specifically at preparing NASA to support future human exploration of the Moon. A science community-based Objectives and Development Team, in coordination with other related offices within NASA, developed and approved requirements for the Orbiter in March 2004. NASA released the competitive Announcement of Opportunity for the Orbiter's instrument payload on June 18. The Agency also initiated activities that will ensure broad community involvement in long-term robotic lunar exploration planning beyond 2008 (e.g., science priority recommendations, mission trade studies, and investigation pathways). As part of the larger effort to implement NASA's Vision for Space Exploration, NASA's Exploration Systems Mission Directorate also identified, catalogued, and evaluated pertinent past lunar exploration architecture concepts and trade studies necessary for formulating options and requirements for future human-robotic exploration.

Outcome 5.13.2: Conduct robotic missions, in lunar orbit and on the lunar surface, to acquire engineering and environmental data by 2015 required to prepare for human-robotic lunar missions.

See discussion under Outcome 5.13.1.

Outcome 5.13.3: By 2020, establish through lunar surface missions the building block capabilities to support safe, affordable and effective long-duration human presence beyond low Earth orbit (LEO) as a steppingstone to sustained human-robotic exploration and discovery beyond the Moon.

See discussion under Outcome 5.13.1.

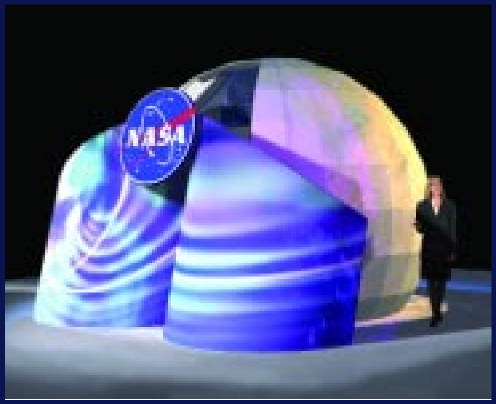
Outcome 5.13.4: By 2015, demonstrate new human-robotic space operations capabilities employing advanced in-space infrastructures, including space assembly, maintenance and servicing, and logistics concepts.

See discussion under Outcome 5.13.1.

Performance Measures for Objective 5.13		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 5.13.1	Develop capability to conduct robotic lunar test bed missions by 2008 and human lunar missions as early as 2015 but no later than 2020 that can demonstrate exploration systems and architectural approaches, including use of lunar resources, to enable human–robotic exploration across the solar system.	green		Outcomes originated in FY 2004		
APG 4LE1	Identify and analyze past architecture-definition and trade studies with applicability to lunar human–robotic exploration tests.	green		none	none	none
Outcome 5.13.2	Conduct robotic missions, in lunar orbit and on the lunar surface, to acquire engineering and environmental data by 2015 required to prepare for human–robotic lunar missions.	green		Outcomes originated in FY 2004		
Outcome 5.13.3	By 2020, establish through lunar surface missions the building block capabilities to support safe, affordable and effective long-duration human presence beyond low Earth orbit (LEO) as a steppingstone to sustained human–robotic exploration and discovery beyond the Moon.	green		Outcomes originated in FY 2005		
Outcome 5.13.4	By 2015, demonstrate new human–robotic space operations capabilities employing advanced in-space infrastructures, including space assembly, maintenance and servicing, and logistics concepts.	green		Outcomes originated in FY 2006		

Mission: To Inspire the Next Generation of Explorers

Goal 6: Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.



Goal 7: Engage the public in shaping and sharing the experience of exploration and discovery.

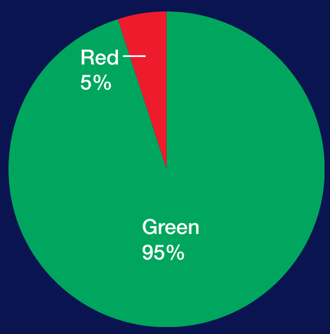
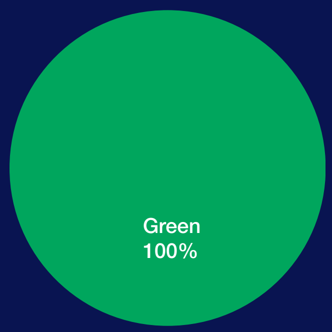


Figure 108: NASA achieved 95 percent of the APGs in Goal 6.



NASA is on track to achieve 100 percent of its Outcomes under Goal 6.

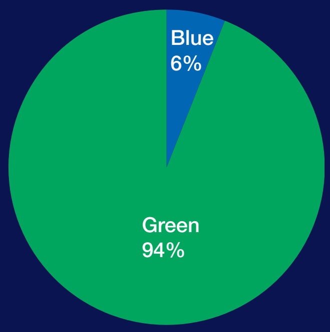
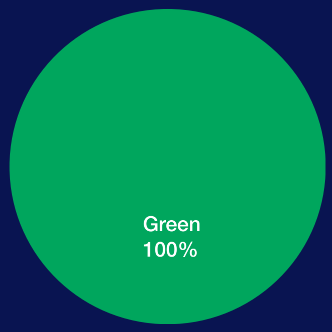


Figure 109: NASA achieved 100 percent of the APGs in Goal 7.



NASA is on track to achieve 100 percent of its Outcomes under Goal 7.

APG color ratings:

- Blue: Significantly exceeded APG
- Green: Achieved APG
- Yellow: Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
- Red: Failed to achieve APG, do not anticipate completion within the next fiscal year.
- White: APG was postponed or cancelled by management directive.

Outcome color ratings:

- Blue: Significantly exceeded all APGs. On track to exceed this Outcome as stated.
- Green: Achieved most APGs. On track to fully achieve this Outcome as stated.
- Yellow: Progress toward this Outcome was significant. However, this Outcome may not be achieved as stated.
- Red: Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
- White: This outcome as stated was postponed or cancelled by management directive or the Outcome is no longer applicable as stated based on management changes to the APGs.

Goal 6 Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.

OBJECTIVE 6.1

Increase the number of elementary and secondary students and teachers who are involved in NASA-related education opportunities.

WHY PURSUE OBJECTIVE 6.1?

To inspire the next generation of scientists, technologists, engineers, and educators, NASA cannot rely on the past. The Agency has to engage the education community and invite them to participate in ongoing work and the process of discovery. With its ability to capture the imagination of educators, students, and the general public, NASA has a unique capacity to help revitalize science, technology, engineering, and mathematics (STEM) education in America.

Figure 110: NASA-sponsored education programs demonstrate the relationship between NASA's research and textbook learning. Here, students measure and record plant height for a graphing exercise using *Brassica rapa* plants, a member of the mustard plant family that has been used for research on the Shuttle, the Russian space station *Mir*, and the International Space Station.

When students are inspired, they are motivated to learn more and assume more difficult challenges, such as those posed in the study of higher levels of STEM. To continue challenging these students, educators must have the tools, experiences, and opportunities to further their own education in STEM areas. NASA provides scientific content, advanced technological tools, and supplemental educational services as part of an educational pipeline that extends from elementary through secondary education and beyond. NASA partners with external agencies and organizations, including national, state, and local education associations, to meet the needs of America's educational community at all levels.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 6.1.1: By 2008, increase by 20%, student participation in NASA instructional and enrichment activities.

In FY 2004, NASA implemented the Educator Astronaut Program and the NASA Explorer Schools Program. Student participation increased by 100 percent for both programs. Through these programs, students participate in a rich array of individual and group-learning activities.

The Educator Astronaut Program directs talented and diverse students and researchers into targeted opportunities and experiences leading to NASA-related career possibilities and decisions. This fiscal year, NASA registered 122,899 people as Earth Crew members, the ground-based component of the Educator Astronaut Program. Approximately 87,000 of these Earth Crew members are students. NASA also trained 181 teachers in the Network of Educator Astronaut Teachers who will interact with approximately 9,000 teachers this year to give them NASA content and teaching strategies for their classrooms.

The Agency also doubled the number of schools in the NASA Explorer School Program. One hundred schools now participate, and an additional 50 schools are anticipated to participate during FY 2005. The Explorer Schools Program currently reaches 70,000 students.

In FY 2004, NASA also achieved the following:

- NASA's Science, Engineering, Mathematics, and Aerospace Academy served 17,148 students in 796 primary and secondary schools in 57 counties across the continental United States, resulting in a 37 percent increase.

Figure 111: The three educator astronaut candidates from the 2004 astronaut class participate in an Earth Crew Webcast on May 6, 2004: (from left) Dorothy (Dottie) Metcalf-Lindenburger, Richard (Ricky) Arnold II, and Joseph (Joe) Acaba.

- Twenty-seven thousand participants joined in STEM-related activities nationwide as part of NASA's Saturday Academy Programs.
- NASA's Science, Engineering, Communication, Mathematics Enhancement Program reached 39,326 students in FY 2004. Participating students average overall Scholastic Aptitude Test scores of 1155 versus the national average of 946.
- The Summer High School Apprenticeship Research Program placed 382 summer student interns at NASA's Centers and partner universities.

Outcome 6.1.2: By 2008, increase by 20%, the number of elementary and secondary educators effectively utilizing NASA content-based STEM materials and programs in the classroom.

The NASA Explorer Schools Program increased the number of competitively selected participating schools to 100. Educators in these schools participate in a variety of individualized professional development activities where they are introduced to NASA materials ranging from lesson guides to interactive multimedia programs. NASA currently is conducting an independent evaluation of the program to determine the degree to which the resources are used effectively. NASA also achieved the following:

- The Educator Astronaut Programs' Network of Educator Astronaut Teachers Activity continued to give participants an opportunity to utilize NASA materials and participate in curriculum development.
- The Edspace Web site (http://edspace.nasa.gov) continued to provide content based on astronaut training for educators to use in the classroom.
- The Science, Engineering, Communication, Mathematics Enhancement Program hosted several workshops for educators. In FY 2004, 8,412 teachers in the program used NASA content-based STEM materials.

Outcome 6.1.3: By 2008, increase by 20%, family involvement in NASA-sponsored elementary and secondary education programs.

NASA made progress in incorporating family involvement into selected activities primarily through the Science, Engineering, and Mathematics Aerospace Academy. The Academy involves families

Figure 112: NASA provides educators with professional development activities and materials that help them bring the excitement of space to the classroom.

through the Family Café, an interactive forum that provides educational and parenting information to adult caregivers and other supportive adults who are involved actively in the student's life. The Family Café also puts these adults in touch with various local resources and programs that are available for the student. Beginning in FY 2005, family involvement also will become a part of every NASA Explorer School visit by NASA education specialists. Other activities include the following:

- NASA Centers invited family members and the community to attend the opening and closing ceremonies for NASA's Summer High School Apprenticeship Research Program.
- NASA's Science, Engineering, Communication, Mathematics Enhancement Program includes a family component in its programs. In FY 2004, 27,483 parents participated in the related Empowering Parents to Excel at Parenting program. In an annual program performance evaluation, chartered by the Office of Education and using standard criteria, Excel at Parenting received an overall rating of 4.45 out of a possible 5.0.

Outcome 6.1.4: By 2008, 90% of NASA elementary and secondary programs are aligned with state or local STEM educational objectives.

NASA education program managers involve local educators in program planning to ensure alignment with state and local education standards. Some programs, like the NASA Explorer Schools, require a needs assessment to assist in the determination and matching of appropriate NASA materials and programs that will be provided through professional development. Currently, NASA keeps education information on every state and Puerto Rico, Guam, and the Virgin Islands in the NASA State Directory which is accessible via the NASA Portal (www.nasa.gov). All Aerospace Education Services Program specialists receive state-based training and are knowledgeable in the frameworks of their assigned states. A peer-review assessment of the alignment will be conducted in the near future.

Performance Measures for Objective 6.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 6.1.1	By 2008, increase by 20%, student participation in NASA instructional and enrichment activities.	green		Outcomes originated in FY 2004		
APG 4ED1	Develop protocols to establish a baseline of NASA student participation.	green		none	none	none
APG 4ED2	Develop and implement at least one model program, based on best practices, that engages students in NASA science and technology (inclusive of the science and technical Enterprises).	green		none	none	none
Outcome 6.1.2	By 2008, increase by 20% the number of elementary and secondary educators effectively utilizing NASA content-based STEM materials and programs in the classroom.	green		Outcomes originated in FY 2004		
APG 4ED3	Develop protocols to establish a baseline of NASA teacher participation.	green		none	none	none
APG 4ED4	Develop and implement a model program, based on best practices, that engages teachers in NASA science and technology (inclusive of the science and technical Enterprises).	green		none	none	none
Outcome 6.1.3	By 2008, increase by 20% family involvement in NASA-sponsored elementary and secondary education programs.	green		Outcomes originated in FY 2004		
APG 4ED5	Establish a baseline of existing NASA sponsored family involvement activities and existing and potential partners.	green		none	none	none
APG 4ED6	Using an established best-practices model, implement one NASA-sponsored family involvement component/program at each Center.	green		none	none	none
Outcome 6.1.4	By 2008, 90% of NASA elementary and secondary programs are aligned with state or local STEM educational objectives.	green		Outcomes originated in FY 2004		
APG 4ED7	Establish a baseline to determine the number of states in which NASA state-based programs are being implemented.	green		none	none	none

Goal 6
Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.

OBJECTIVE 6.2

Support higher education research capability and opportunities that attract and prepare increasing numbers of students and faculty for NASA-related careers.

WHY PURSUE OBJECTIVE 6.2?

The NASA Mission—to understand, explore, and inspire—depends on people with the ingenuity to invent new tools, the passion to solve problems, and the courage to ask difficult questions. However, recent data indicates a decline in the number of students pursuing degrees in the disciplines of science, technology, engineering, and mathematics. Combined with a shortage of mathematics, science, and technology teachers, an aging aerospace workforce, and employee recruitment competition, the future of U.S. advancements in science, aeronautics, and aerospace is at risk.

Figure 113: The NASA workforce of tomorrow is being trained today in our institutions of higher education.

NASA is strengthening involvement with higher education institutions to meet the Agency's future workforce needs by encouraging more students to continue their studies and earn advanced degrees in these critical fields. NASA is improving coordination between NASA-sponsored university research activities and teacher preparation programs to expose teachers-in-training to NASA research and discoveries. Through faculty development opportunities, NASA also is increasing the candidate pool of qualified faculty and institutions that can compete for NASA research awards. NASA has an inspiring mission of exploration and discovery and world-class laboratories and facilities. The Agency provides students, teachers, and professionals access to this wealth of information and capabilities through scholarship programs, research grants, and other opportunities—bringing these future scientists, engineers, and mathematicians into the NASA family.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 6.2.1: By 2008, attain a statistically significant increase in the number and diversity of NASA-supported students graduating in NASA-related fields.

In FY 2004, NASA developed a baseline of the number of students supported by the Agency. NASA also collected demographic data to measure diversity. The Science and Technology Scholarship Program will be fully implemented in FY 2005 and will add to the base of NASA-supported students.

Outcome 6.2.2: By 2008, attain a statistically significant increase in the number of faculty in higher education institutions who are first-time proposers in NASA research and development opportunities.

NASA's programs for faculty are designed to involve new faculty in NASA research, especially those at historically underserved, underrepresented universities and colleges. Currently, substantial anecdotal evidence indicates that NASA is helping faculty members develop and submit high-quality proposals for the first time and is on track to achieve this Outcome. NASA also has added new data elements to track the number of faculty who propose for the first time. By implementing a tracking system to collect this data, the Agency will be able to document performance on this Outcome.

Outcome 6.2.3: By 2008, increase by 20% the number of higher education institutions that align their NASA research and development activities with STEM teacher preparation departments to improve STEM teacher quality.

NASA made progress toward increasing the number of higher education programs that align NASA activities with STEM teacher preparation through two pre-service education programs. The first, NASA's Project NOVA, is a national pre-service activity that collaborates with science, engineering, and education departments to prepare the next generation of teachers. Faculty at NOVA institutions represent both science and education departments involved in teacher preparation. Ninety-two institutions in 34 states and more than 750 university faculty members have participated in the program. NOVA has reached more than 40,000 university students and participating universities and colleges have created more than 150 new/modified courses.

Figure 114: NASA provides undergraduate and graduate students with the opportunity to fly experiments on the KC-135, shown here, and is looking to increase opportunities to fly experiments on the International Space Station.

The second program, the NASA Langley Pre-Service Teacher Program, is a partnership with Norfolk State University's School of Science and Technology. The program provides pre-service teachers and faculty members with opportunities to enhance their knowledge and skill in teaching mathematics and science using technology at the elementary and middle school levels. The FY 2004 Pre-Service Teacher Conference hosted approximately 700 prospective teachers from selected Historically Black Colleges and Universities, Hispanic Serving Institutions, Tribal Colleges and Universities, and some majority institutions.

Outcome 6.2.4: By 2008, increase by 10% the number and diversity of students conducting NASA-relevant research.

NASA initiated several activities in FY 2004 to engage students in NASA research. Currently, programs like the Undergraduate Student Research Program and its companion, the Graduate Student Research Program, engage students in research at NASA Centers. NASA also is creating a Flight Projects Office to help in this effort. This office will facilitate research opportunities for students using flight platforms like the International Space Station. Students also are proposing and flying experiments on NASA's KC-135, a plane that flies a special flight pattern to simulate periods of weightlessness. NASA continues to develop the infrastructure, staffing, and opportunities necessary to support these activities.

Performance Measures for Objective 6.2		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 6.2.1	By 2008, attain a statistically significant increase in the number and diversity of NASA-supported students graduating in NASA-related fields.	green		Outcomes originated in FY 2004		
APG 4ED8	Establish a NASA-wide baseline of the number and diversity of NASA-supported students.	green		none	none	none
Outcome 6.2.2	By 2008, attain a statistically significant increase in the number of faculty in higher education institutions who are first-time proposers in NASA research and development opportunities.	green		Outcomes originated in FY 2004		
APG 4ED9	Develop an inventory identifying the number of first-time proposers and the universe of faculty in higher education institutions involved with NASA research and development opportunities.	red		none	none	none
Outcome 6.2.3	By 2008, increase by 20% the number of higher education institutions that align their NASA research and development activities with STEM teacher preparation departments to improve STEM teacher quality.	green		Outcomes originated in FY 2004		
APG 4ED10	Develop a model to demonstrate how NASA's investment in higher education institutions can influence the quality of pre-service education in STEM fields.	green		none	none	none
Outcome 6.2.4	By 2008, increase by 10% the number and diversity of students conducting NASA-relevant research.	green		Outcomes originated in FY 2004		
APG 4ED11	Develop an infrastructure and funding plan that provides Education sponsored flight research opportunities (including STS, ISS, ELV, balloons, and sounding rockets) for graduate, undergraduate, and selected high school students.	green		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 6 Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.

OBJECTIVE 6.3

Increase the number and diversity of students, teachers, faculty and researchers from underrepresented and underserved communities in NASA related STEM fields.

WHY PURSUE OBJECTIVE 6.3?

Increasing the number of students that become inspired to study and enter into science, technology, engineering, and mathematics (STEM), as well as teaching career fields, requires NASA to expand its existing educational opportunities and create new opportunities. NASA strives to reach underrepresented and underserved students and to encourage more of these students to pursue STEM careers. To help achieve this, NASA recognizes the role of teachers, faculty, and families in developing successful students. NASA continues to focus on enhancing the capabilities of Historically Black Colleges and Universities, Hispanic Serving Institutions, and Tribal Colleges and Universities to contribute to the Agency's research needs. NASA also encourages these institutions to collaborate with teacher preparation programs to improve the quality and diversity of STEM teachers. National, state, and local associations, organizations, and institutions knowledgeable about the needs and capabilities of underrepresented and underserved populations guide NASA's program development and implementation.

Figure 115: NASA provides educational opportunities and tools that encourage students to study science, technology, engineering, and mathematics.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 6.3.1: By 2008, increase by 20%, underrepresented/underserved NASA-sponsored students who pursue academic degrees in NASA-related STEM disciplines.

NASA made progress toward increasing sponsorships of underrepresented/underserved students in STEM disciplines by including underserved students in the Agency's education program evaluation protocols. NASA used these protocols in program reviews and determined that the Agency is making good progress toward including a greater diversity of participants. NASA also developed a new scholarship program for underrepresented and underserved students to be implemented fully in FY 2005.

Outcome 6.3.2: By 2008, increase by 20%, the number and diversity of teachers and faculty from underrepresented/underserved communities and institutions who participate in NASA-related STEM programs.

NASA made progress toward increasing the number and diversity of underrepresented/underserved teachers participating in STEM programs by implementing an education portfolio assessment review process that emphasizes diversity. The assessment reflects good progress toward this Outcome.

Outcome 6.3.3: By 2008, increase by 20% the number of underrepresented/underserved researchers and minority serving institutions that compete for NASA research and development opportunities.

NASA made progress toward increasing the number of underrepresented/underserved researchers competing for NASA research and development opportunities by providing ten technical assistance workshops for minority institutions. NASA also protected minority university program funding from potential Agency budget reductions. These actions will ensure that minority researchers continue to be included in the NASA competition process. NASA also established a baseline for this Outcome, and the Agency is confident that the planned increases will occur.

Outcome 6.3.4: By 2008, increase family involvement in underrepresented/underserved NASA-sponsored student programs.

NASA made progress toward increasing family involvement through the Science, Engineering, and Mathematics Aerospace Academy. In addition to locating 13 of the Academy sites at minority institutions, the Academy involves families through the Family Café, an interactive forum that provides educational and parenting information to adult caregivers who are involved in the student's life. The Family Café model also was adopted by the Science, Engineering, Communication, and Mathematics Enhancement Program which serves underserved and underrepresented students.

Performance Measures for Objective 6.3		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 6.3.1	By 2008, increase by 20% underrepresented/underserved NASA-sponsored students who pursue academic degrees in NASA-related STEM disciplines.	green		Outcomes originated in FY 2004		
APG 4ED12	Develop protocols to establish a baseline of NASA underrepresented/ underserved student participation.	green		none	none	none
APG 4ED13	Develop a model undergraduate program, based on best practices, bridging current programs, that engages underrepresented/underserved students.	green		none	none	none
Outcome 6.3.2	By 2008, increase by 20% the number and diversity of teachers and faculty from underrepresented/underserved communities and institutions who participate in NASA-related STEM programs.	green		Outcomes originated in FY 2004		
APG 4ED14	Develop protocols to establish a baseline of NASA underrepresented/ underserved teacher/faculty participation in NASA STEM-related learning environments.	green		none	none	none
Outcome 6.3.3	By 2008, increase by 20% the number of underrepresented/underserved researchers and minority serving institutions that compete for NASA research and development opportunities.	green		Outcomes originated in FY 2004		
APG 4ED15	Establish a baseline of the numbers of underserved/underrepresented researchers and minority serving institutions competing for NASA research announcements.	green		none	none	none
APG 4ED16	Conduct 3 technical assistance workshops.	green		none	none	none
Outcome 6.3.4	By 2008, increase family involvement in underrepresented/underserved NASA-sponsored student programs.	green		Outcomes originated in FY 2004		
APG 4ED17	Using an established best-practices model, pilot a NASA-sponsored family involvement component in one underrepresented/underserved NASA-sponsored student program.	green		none	none	none

Goal 6 Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.

OBJECTIVE 6.4

Increase student, teacher, and public access to NASA education resources via the establishment of e-Education as a principal learning support system.

WHY PURSUE OBJECTIVE 6.4?

In the future, powerful technologies will enable new learning environments using simulations, visualizations, immersive environments, gameplaying, and learner networking. These capabilities will create rich and compelling learning opportunities that meet the needs of learners while empowering educators to unlock each student's potential. Learning will be on demand. Students and educators will receive what they need, when they need it—anytime, anywhere. NASA is working toward this education future, developing new methods for making its exciting discoveries and valuable resources available to students, educators, and teachers. The Agency is continually challenged to develop a delivery system that is timely and accurate while protecting the intellectual capital of research scientists. NASA is committed to finding the right balance in this challenge so that educators and students will continue to have access to NASA's engaging science content through digital media.

Figure 116: NASA uses the Web to give students and educators around the country easy access to a wide variety of unique activities and resources.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 6.4.1: By 2008, identify and implement 4 new advanced technology applications that will positively impact learning.

The NASA Learning Technologies Initiative creates teaching tools and applications to deliver NASA content in the most engaging and dynamic ways possible. An expert panel selected the current suite of four tools from an initial testbed of ten projects based on their feasibility and application to the classroom. The four projects are now in their second year of a three-year product development cycle, they include: the Johnson Space Center *Learning Technology Information Accessibility Lab*, the Kennedy Space Center *Learning Technology Virtual Lab*, the Ames Research Center *Learning Technology* "What's the Difference?" project, and the Goddard Space Flight Center *Animated Earth* project.

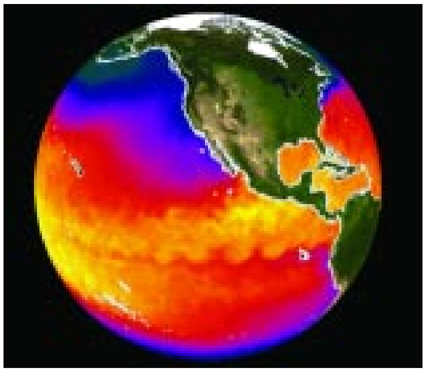


Figure 117: The Animated Earth is just one of the education components of NASA's Learning Technologies Project, which uses both new and entrenched technologies to provide education tools for science and math. This image uses NASA Earth science data to show global sea-surface temperatures.

In FY 2004, NASA also reviewed existing learning technologies and selected ten cognitive tools to include in the NASA-sponsored Classroom of the Future's Virtual Design Center. The Classroom of the Future also analyzed two thinking tools, visual ranking and seeing reason, developed by the Intel Education Foundation. The Virtual Design Center Editorial Board (a group of world-class researchers in educational psychology, learning sciences, and instructional technology), favorably reviewed the tools and both will be added to the Virtual Design Center. As part of the Classroom of the Future program, NASA also is planning empirical studies examining the benefits of three-dimensional visualization, comparative interfaces, graph sonification, and virtual data collection.

Another activity contributing to this Outcome was NASA's participation in the Summer 2004 National Science Teachers Association Retreat on the topic of "Anticipating the Role of Emerging Technologies in Science Education." Fifteen leaders in the field of science education and educational technology, including educators and representatives from NASA's Office of Education, attended the three-day retreat. Representatives from the following institutions also attended: Intel Research, Microsoft Research, Harvard University, Texas Instruments, the University of Georgia, the Education Development Center, Inc., Stanford University, University of Michigan, Concord Consortium, and Vernier, Inc.

Outcome 6.4.2: By 2008, demonstrate the effectiveness of NASA digital content materials in targeted learning environments.

NASA made progress toward this Outcome by using a university-developed survey assessment, the Teaching, Learning, and Computing Instrument, to evaluate materials used with the Explorer Schools Program. The comprehensive evaluation is a major component of the Explorer Schools program. Although the APG 4ED19 specifically refers to the School Technology And Readiness (STAR) tool for conducting the assessment, NASA instead used the Teaching, Learning, and Computing Instrument to capture the parts of the STAR instrument that were most relevant for NASA's Explorer Schools. As part of this process, NASA conducted a technology assessment at 47 of the 50 Explorer Schools. The results indicated that the majority of schools had limited technical capacity. Less than one-third of the schools had onsite technical support; less than ten percent had videoconferencing equipment. Through a partnership with ClearOne Communications, many of the Explorer Schools now have donated videoconferencing equipment to meet the needs identified by the technology survey. The Teaching, Learning, and Computing survey is available online through the Wheeling Jesuit University's Center for Educational Technologies.

Outcome 6.4.3: By 2008, establish a technology infrastructure that meets citizen demand for NASA learning services.

NASA performed several different surveys and assessments to capture the current state, needs, and recommendations from an array of NASA assets and customers. NASA is using the findings to make ongoing improvements to infrastructure and to identify necessary tasks and activities for implementation in FY 2005. Examples include the following:

- The University of Texas–El Paso completed a technology survey of the NASA Center Education Offices infrastructure.
- Over 65 Educator Resource Centers within NASA's network participated in a technology survey.
- The Center for Educational Technologies completed the Teaching, Learning, and Computing Survey on the NASA Explorer Schools sites.
- NASA conducted a user survey on NASA Television, its current usage and its projected usage if the format was digital.
- NASA continues to conduct an ongoing user survey utilizing the ForeSee Survey instrument.

Performance Measures for Objective 6.4		2004 Rating	Past Years' Performance Measures and Ratings 2003	2002	2001
Outcome 6.4.1	By 2008, identify and implement 4 new advanced technology applications that will positively impact learning.	green	Outcomes originated in FY 2004		
APG 4ED18	Benchmark advanced technology tools/applications under development to determine the 4–6 with the most impact potential for NASA e-learning.	green	none	none	none
Outcome 6.4.2	By 2008, demonstrate the effectiveness of NASA digital content materials in targeted learning environments.	green	Outcomes originated in FY 2004		
APG 4ED19	Assess at least 25 of the NASA explorer schools, utilizing the School Technology and Readiness (STaR) tool.	green	none	none	none
Outcome 6.4.3	By 2008, establish a technology infrastructure that meets citizen demand for NASA learning services.	green	Outcomes originated in FY 2004		
APG 4ED20	Perform a NASA learning services technology infrastructure needs assessment.	green	none	none	none

Goal 7
Engage the public in shaping and sharing the experience of exploration and discovery.

OBJECTIVE 7.1

Improve public understanding and appreciation of science and technology, including NASA aerospace technology, research, and exploration missions.

WHY PURSUE OBJECTIVE 7.1?

As NASA pursues its exploration goals, the Agency seeks to engage the public by communicating the benefits of its scientific discoveries, technological breakthroughs, and spinoffs relevant to the daily lives of all citizens. To do this, NASA is creating and leveraging informal partnerships to share the Agency's discoveries and experiences. These new, informal partners include science

Figure 118: A family takes a close look at the displays at NASA's Centennial of Flight exhibit, held in December 2003 in Kitty Hawk, North Carolina.

centers, museums, planetariums, community-based organizations, and other public forums. NASA also is working with all Agency partners to develop and disseminate educational materials that incorporate new discoveries. In addition, NASA will continue to work with these partners to create and deliver professional development programs for educators. A more science-literate society can make better decisions to define the technological developments that will shape the future.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 7.1.1: By 2008, establish a national program to engage the informal education community with NASA Science and Technology.

In FY 2004, NASA made excellent progress in engaging the informal education community through a number of collaborative initiatives. First, Northwestern University developed two reports (*American Attitudes toward Space Exploration and Attitudes of Space Policy Leaders*) assessing public perceptions and the needs of the informal community. Second, NASA sponsored a research project that created a database containing ten years of community attitudes and survey results. Third, NASA conducted focus groups in eight locations across the country, and the Center for Cultural Studies and Analysis also conducted a cultural analysis for NASA (*American Perception of Space Exploration*). Finally, NASA issued a grant to Dr. Sally Ride to develop baselines and begin evaluation strategies for the Sally Ride Festivals, which bring together hundreds of middle-school girls for a festive day of science and inspiration.

Outcome 7.1.2: By 2008 provide instructional materials derived from NASA research and scientific activities that meet the needs of NASA's informal education partners.

In FY 2004, NASA made progress in this area through a number of initiatives. The Agency developed a baseline of resources for the informal community. In addition, the American Museum of Natural History surveyed over 200 NASA resources to determine their usefulness to the informal education community. NASA also created, in association with over 130 organizations, the Mars Museum Visual Alliance to provide access to, and use of, data, images, and live updates from NASA's Mars rovers. NASA also helped the Denver Museum of Nature and Science develop Space Odyssey programs. Finally, NASA worked with the Challenger Learning Center to develop the Journey through the Universe program.

Outcome 7.1.3: By 2008 provide professional development for NASA's informal education partners.

NASA has implemented six Explorer Institutes to provide professional development opportunities for informal educators, and the Institutes are developing an inventory of resources available to the informal education community through NASA's Centers. NASA's partners in supporting the Institutes include: National Park Service, University of California at Berkeley, DePaul University, Southeast Regional Clearing House, Girl Scouts of the USA, Space Telescope Science Institute, Harvard–Smithsonian Astrophysical Observatory, Florida Space Grant Consortium, Kennedy Space Center Visitor Complex, Space Center Houston, Maryland Science Center, Science Museum of Minnesota, New England Aquarium, Northwestern University, Society for Amateur Scientists, North Carolina 4H clubs, Virginia Air and Space Center, and the Return to Flight Museum Commission. NASA also issued a Cooperative Agreement Notice to provide members of the informal education community with an opportunity to compete for funding support to host NASA Explorer Institute Focus Groups. These Focus Groups will assemble experts from the informal education community to further identify strategies and approaches that can be used to implement the NASA Explorer Institutes Program.

Outcome 7.1.4: Engage the public in NASA missions, discoveries and technology through public programs, community outreach, mass media, and the Internet.

Every NASA organization is charged with engaging the public in NASA's missions, discoveries, and technology through public outreach. As always, the Agency's outreach initiatives in FY 2004 touched the public at every level and ignited citizen interest in, and support for, the Nation's space program.

Many of NASA's public outreach activities in FY 2004 focused on the landings of the two Mars rovers:

- Through the Mars Visualization Alliance, more than a hundred science centers, museums, and planetariums brought the excitement of the Mars landings and the subsequent science explorations to the public in near-real-time through special events held at each of their facilities.
- The Passport to Knowledge series followed the progress of the Mars rovers through a series of special broadcasts for the education community and the general public.
- On January 17, "First Look" was broadcast live from the Houston Museum of Natural Science and NASA's Jet Propulsion Laboratory. Coming shortly after the January 3 landing of the first rover, *Spirit*, the program focused on the initial science activities conducted by the rover.
- On May 1, the St. Louis Science Center and NASA's Jet Propulsion Laboratory broadcast "New Views from Mars," an update on Mars Exploration Rover science on participating PBS stations and NASA Television as a service to science centers, schools, and non-commercial media.
- A new version of the "MarsQuest" exhibition, featuring the latest discoveries from the Mars rovers and a new Mars exhibit called "Destination Mars," began its national tour at the New Detroit Science Center in Detroit, Michigan. Saturn took center stage in July, with the Cassini–Huygens spacecraft arriving at Saturn and entering into an orbit around the ringed planet. For this event, the Mars Visualization Alliance transformed into the Saturn Alliance, giving the participating science centers, museums, and planetariums opportunities to hold special events to monitor and celebrate Cassini's orbital insertion, and the subsequent scientific explorations of Saturn and its moons.

Cassini's arrival at Saturn also provided exciting outreach opportunities, including the "Ringworld" planetarium show, a major feature at many participating planetariums around the country during the major Cassini mission events in FY 2004.

In addition to the Mars rovers and Cassini mission successes, an exceedingly rare celestial event occurred in FY 2004—the transit

Credit: NASA/T. Cline

Figure 119: A rare transit of Venus across the face of the Sun provided education opportunities on subjects ranging from the size of the solar system to the scale of the entire universe.

of Venus across the Sun. Starting at sunrise on June 8, 2004, Venus was visible to properly prepared viewers as it moved across the face of the early morning sun. The Venus Transit offered researchers, scientists, and educators the opportunity to highlight the historical significance of such an event in making scientific observations that range from studying the atmosphere of Venus to determining the distance scale of the universe. NASA made a number of resources available to students and teachers: a NASA/CONNECT television program about how the transit of Venus set the scale of the solar system; a Student Observation Network laboratory experiment on determining the distance from Earth to the Sun using transit observations; and multi-curricular resources in science, math, history, literature, arts, and music. In addition, the entire transit was Webcast by the Exploratorium from a site in Athens, Greece, and "Chasing Venus," a special exhibition featuring materials and historical documents from past transits compiled by the Dibner Library of the Smithsonian Institution, was on display at the National Museum of American History.

NASA also ignited public interest with Earth science-related outreach activities that included the Earth Observatory Web site (www.earthobservatory.nasa.gov), which posted 178 feature stories and 60 reference articles in FY 2004. In addition, NASA issued more than 70 press releases dealing with Earth science news stories.

As always, NASA had a successful year exciting public interest in space operations, increasing by more than ten percent the venues that provided "hands-on" opportunities for the public to engage in and understand the benefits of space flight and the International Space Station. The Agency reached and engaged an estimated audience of over four million people—two million more people than were reached in 2003. Examples of activities in this area include the following:

- The Astro Camp at Stennis Space Center, the Vision Station at Glenn Research Center, the photo opportunity exhibit, the Shuttle Launch Experience, and the Vision Exhibit at Marshall Space Flight Center provided highly interactive ways for visitors to learn about flight dynamics, landing the Shuttle, the International Space Station, space flight benefits, and Moon and Mars exploration.
- NASA participated in more than 780 Speaker's Bureau local, national, and international events, reaching estimated audiences in excess of 300,000. The Kennedy Space Center alone supported 348 Speaker's Bureau events reaching a total audience of nearly 130,000 people.
- NASA supported approximately 1,800 Astronaut Events as a result of Explorer School visits.
- NASA's Visitor's Centers welcomed approximately 1,831,287 visitors in FY 2004—about 40,000 more visitors than in FY 2003.
- NASA produced over 260,000 products related to space operations (e.g., feature articles, bookmarks, videos, fact sheets, postcards, and posters) compared to approximately 166,000 in FY 2003.
- In FY 2004, the Johnson Space Center and the Kennedy Space Center conducted over 200 media events that reached over 231,000,000 viewers, a 10 percent increase over FY 2003.

Figure 120: Members of the band Aerosmith encourage students to "Dream On" during their visit to Johnson Space Center in February 2004.

- In February 2004, the rock band Aerosmith toured the Johnson Space Center and recorded a public service announcement that aired on 12 major networks and reached millions of viewers around the world. The announcement featured space exploration imagery set to the track of Aerosmith's song "Dream On." The message from Steven Tyler, Aerosmith's lead singer, and Joe Perry, Aerosmith's lead guitarist, is that they have traveled all over the world and now NASA's rocket scientists are making it possible to travel to other worlds. Their message to the audience, specifically to students, was that "they will want to be part of this amazing journey, so study hard, stay in school and dream on."

Credit: T. Tschida

Figure 121: Eddie Patterson, a fourth-grade student at Tehachapi's Tompkins Elementary School, enjoyed "flying" a C-17 multi-engine aircraft simulator during Take Your Children to Work Day, held June 22, 2004, at NASA Dryden Flight Research Center, while Dryden engineer Ken Norlin and other students look on. NASA uses a variety of special events to communicate the adventures of flight and space exploration, and the benefits of NASA research and technology, to children and adults.

- NASA conducted International Space Station Trailer tours in 23 cities across the United States, reaching over 100,000 visitors.
- NASA staffed the Space Shuttle Launch Experience Theater at the Association of American Museums Annual Conference in New Orleans.

- NASA's Marshall Space Flight Center presented a "One NASA" Vision booth at the National Space Symposium in Colorado Springs. Approximately 2,000 conference attendees, representing government, military, and industry leaders, toured the exhibit.
- NASA participated in every major Centennial of Flight event featuring the Agency's new 10,000 square foot Centennial of Flight exhibit highlighting NASA's contributions to air and space flight and the Agency's ongoing work toward the future of flight and exploration.
- NASA developed an interactive educational display called *Edgarville Airport—Take Off to the Future of Air Travel*. Developed by NASA's Airspace Systems Program, this three-dimensional, interactive display provides a 180-degree, immersive environment using animated characters to guide users through a virtual airport. Real air traffic controllers explain how air traffic is managed, and the exhibit helps users understand how the National Airspace System operates.
- NASA sponsored space transportation exhibits at six events in FY 2004, reaching more than 113,000 participants: the Aerospace Sciences Meeting and Exhibit (2,500 participants); the National Space Symposium (3,000 participants); the Joint Propulsion Conference (2,000 participants); the Experimental Aircraft Association Oshkosh Airventure (6,000 participants); the Farnborough International Air Show (100,000 participants); and the Space Technology and Application International Forum (300 participants).
- NASA published and distributed three editions of *Aerospace Innovations*, including one special feature issue titled "NASA: Inspiring the Next Generation of Explorers Through Education."
- NASA published and distributed twelve issues of the *NASA Tech Briefs* magazine and the annual edition of *Spinoff*.
- In FY 2004, NASA made 21,467 new NASA technologies considered to be of benefit to U.S. industry available to the public through the NASA TechTracS online database (http://technology.nasa.gov). Technology descriptions include technical briefs, diagrams, and illustrations. This exceeds NASA's annual goal by about 19 percent.

Performance Measures for Objective 7.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 7.1.1	By 2008, establish a national program to engage the informal education community with NASA science and technology.	green		Outcomes originated in FY 2004		
APG 4ED23	Conduct an opinion survey to baseline public attitudes and knowledge of NASA research and exploration.	green		none	none	none
Outcome 7.1.2	By 2008 provide instructional materials derived from NASA research and scientific activities that meet the needs of NASA's informal education partners.	green		Outcomes originated in FY 2004		
APG 4ED21	Compile an inventory of existing programs and partnerships to establish a baseline to assess and prioritize high-leverage and critical informal education programs and educational family involvement activities.	green		none	none	none
Outcome 7.1.3	By 2008, provide professional development for NASA's informal education partners.	green		Outcomes originated in FY 2004		
APG 4ED22	Inventory and assess current NASA professional development programs for relevance to the targeted informal learning environments.	green		none	none	none
Outcome 7.1.4	Engage the public in NASA missions, discoveries, and technology through public programs, community outreach, mass media, and the Internet.	green		Outcomes originated in FY 2004		
APG 4AT16	Partner with external organizations to celebrate the centennial of powered flight highlighting NASA's accomplishments and activities in the advancement of flight.	green		none	none	none
APG 4AT17	Partner with museums and other cultural organizations and institutions to promote NASA achievements to non-traditional audiences, develop and implement a series of traveling exhibitions highlighting NASA activities, develop and distribute informational material related to accomplishments and plans.	green		none	none	none
APG 4ESA6	Provide in public venues at least 50 stories on the scientific discoveries, practical benefits, or new technologies sponsored by the Earth Science Enterprise.	green		none	none	none
APG 4ESS13	Post the most exciting imagery and explanations about Earth science on the Earth observations/ESE Web site.	green		3Y25 green	2Y24 green	1Y18 green
APG 4HRT11	Publish and distribute program specific publications (Aerospace Innovations, NASA Tech Briefs, Spinoff) including 1 industry targeted edition, in a sector where NASA can promise its technologies available for commercialization.	green		none	none	none
APG 4HRT12	Provide public and industry access to the TechTracS database, which features approximately 18,000 updated and evolving new technologies, as well as technical briefs, diagrams, and illustrations.	blue		none	none	none
APG 4RPFS10	Expand outreach activities that reach minority and under-represented sectors of the public, through increased participation in conferences and community events that reflect cultural awareness and outreach. Each fiscal year, increase the previous year baseline by supporting at least one new venue that focuses on these public sectors.	green		none	none	none
APG 4RPFS8	Increase distribution of the Space Research newsletter by 5,000 over FY03 circulation in order to further educate the general public, industry, and academia on space-based research.	green		3B12 green	2B14 green	none
APG 4RPFS9	Through collaboration with PAO, establish and sustain a series of media briefings highlighting OBPR research.	green		none	none	none
APG 4SFS3	Ensure participation of all space flight programs and Centers in increasing by 10% venues that provide "hands-on" opportunities for the public to experience and become more knowledgeable of space flight benefits and contributions, particularly ISS.	green		3H22 green	2H24 yellow	none
APG 4SSE20	Through partnerships with major science museums or planetariums, put on display or on tour major exhibitions or planetarium shows based on Theme content.	green		3S12 green	2S12 blue	1S9 green
APG 4SSE21	Provide materials and technical expertise to support the development of exhibits and programs at science museums and planetariums.	green		none	none	none
APG 4SSE22	Seek out and capitalize on special events and particularly promising opportunities in the Theme science program to bring space science to and involve the public in the process of scientific discovery.	green		none	none	none
APG 4TS4	Space transportation technical exhibits will be sponsored for at least five events reaching over 50,000 participants to improve public appreciation of the ongoing activities and benefits of NASA's space transportation research and technology development efforts.	green		none	none	none

As Only NASA Can: Exploration Capabilities

Goal 8: Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.

Goal 9: Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.

Goal 10: Enable revolutionary capabilities through new technology.

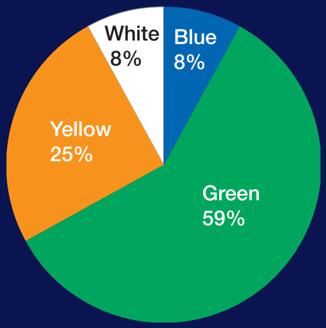
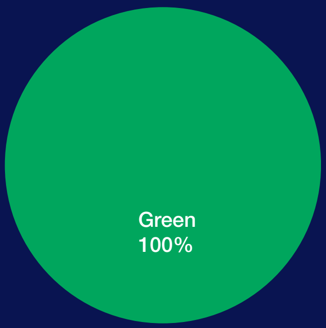


Figure 122:NASA achieved 67 percent of the APGs in Goal 8.



NASA is on track to achieve 100 percent of its Outcomes under Goal 8.

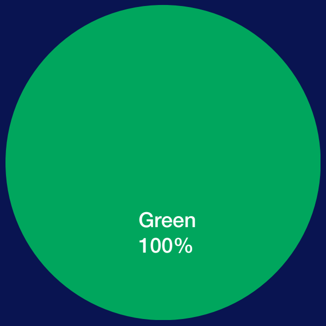
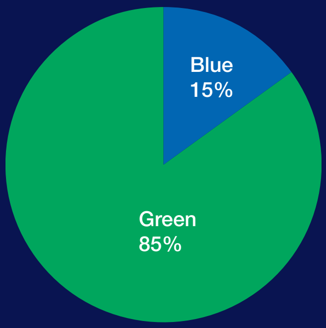


Figure 123: NASA achieved 100 percent of the APGs in Goal 9.



NASA is on track to achieve 100 percent of its Outcomes under Goal 9.

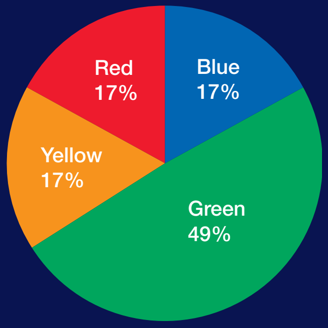
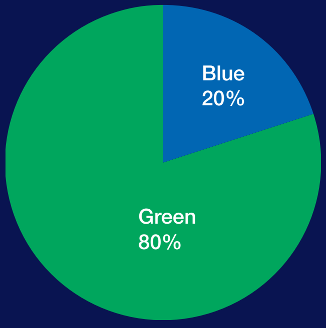


Figure 124: NASA achieved 66 percent of the APGs in Goal 10.



NASA is on track to achieve 100 percent of its Outcomes under Goal 10.

APG color ratings:

- Blue: Significantly exceeded APG
- Green: Achieved APG
- Yellow: Failed to achieve APG, progress was significant, and achievement is anticipated within the next fiscal year.
- Red: Failed to achieve APG, do not anticipate completion within the next fiscal year.
- White: APG was postponed or cancelled by management directive.

Outcome color ratings:

- Blue: Significantly exceeded all APGs. On track to exceed this Outcome as stated.
- Green: Achieved most APGs. On track to fully achieve this Outcome as stated.
- Yellow: Progress toward this Outcome was significant. However, this Outcome may not be achieved as stated.
- Red: Failed to achieve most APGs. Do not expect to achieve this Outcome as stated.
- White: This outcome as stated was postponed or cancelled by management directive or the Outcome is no longer applicable as stated based on management changes to the APGs.

Goal 8
Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.

OBJECTIVE 8.1

Assure safe, affordable, and reliable crew and cargo access and return from the International Space Station.

WHY PURSUE OBJECTIVE 8.1?

The Space Station is the largest science and technology cooperative program in history, drawing on the resources and scientific and engineering expertise of 16 nations. Since the Space Shuttle was grounded after the *Columbia* accident in February 2003, automated Russian Progress vehicles have resupplied the two-person Station crew as needed, and Russian Soyuz vehicles have transported crews safely and reliably to and from the Station. This level of cooperation has enabled a continuous crew presence on the Station.

Figure 125: An Expedition 9 crewmember photographed this Progress 14 vehicle as it approached the International Space Station on May 27, 2004. The unpiloted vehicle was delivering 2.5 tons of food and other supplies.

When the Shuttle fleet returns to flight, the overarching priority will be to complete construction of the U.S. and International phases of the International Space Station safely. In coordination with its partners, NASA will analyze requirements and resources for the Station and decide whether to provide an additional docking node. The partners also will determine how to optimize cargo transportation and resupply operations. NASA also will examine its ongoing reliance on Progress vehicles and evaluate potential commercial sources of transportation. NASA is assessing options to use domestic launch services to augment space access for Station cargo and crew requirements.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 8.1.1: Acquire non-Shuttle crew and cargo access and return capability for the Station by 2010.

Crew and cargo access for the International Space Station is provided using a mixed fleet strategy, including partner vehicles. While the Shuttle is grounded, Russian Soyuz and Progress vehicles provide crew and cargo transportation. In the future, the Launch Services Program will acquire high-quality launch services from commercial providers. NASA released a Request for Information in August 2004 to solicit information concerning available commercial space transportation services, including those needed for International Space Station cargo return services. In FY 2005, NASA will issue a Request for Proposals to begin the process of procuring crew and cargo re-supply services for the Station. To support this effort, the FY 2005 President's Budget includes a line providing for crew and cargo services. In addition, the European Automated Transfer Vehicle and the Japanese H-II Transfer Vehicle, both in development, will play a role in the future as part of a mixed fleet. At this time, only the Shuttle is capable of providing the necessary science cargo return services from the Station.


Credit: NASA/B. Ingalls

Figure 126: While the Shuttle is grounded, Russian Soyuz TMA-3 spacecraft have delivered crewmembers and visiting astronauts from the European Space Agency to the International Space Station. In this picture, a Soyuz spacecraft and its booster rocket, which will deliver the Expedition 8 crew to the Station, is lifted up from a rail car onto its launch pad at Baikonur Cosmodrome, Kazakhstan, on October 16, 2003.

Performance Measures for Objective 8.1		2004 Rating		2003	2002	2001
Outcome 8.1.1	Acquire non-Shuttle crew and cargo access and return capability for the Station by 2010.	green		Outcomes originated in FY 2004		

Note: no APGs in FY 2004; reporting at Outcome level only.

Note: Objective 8.2 was cancelled.

Goal 8
Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.

OBJECTIVE 8.3

Improve the accessibility of space via the Space Shuttle to better meet Space Station assembly, operations, and research requirements.

WHY PURSUE OBJECTIVE 8.3?

As explorers and pioneers, NASA's commitment to space exploration is firm. This includes robotic and human space flight, both of which are essential to the U.S. space program.

Figure 127: Crews help guide an airlock, hanging from a boom in the Orbiter Processing Facility at Kennedy Space Center, into *Discovery*'s bay on May 12, 2004. All three Shuttles have undergone extensive maintenance and safety upgrades to prepare them for return to flight.

The Space Shuttle has been the workhorse for the U.S. space program for more than two decades. The Shuttle of today, however, has evolved significantly from the Shuttle of 20 years ago. Although it looks the same on the exterior, the Shuttle has undergone continuous technological improvements.

NASA is developing an integrated system plan for the Shuttle to improve safety, reliability, and maintainability so that the fleet can better support the International Space Station. Throughout the Station's assembly phase, the Shuttle will be used primarily to lift new Station elements into orbit and meet ongoing Station logistics, resupply, and research requirements.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 8.3.1: 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.

Throughout FY 2004, NASA focused on returning the Space Shuttle to safe flight to complete assembly of the International Space Station, consistent with the Vision for Space Exploration.

Figure 128: The Shuttle *Atlantis* rolls into the Orbiter Processing Facility at Kennedy Space Center on December 16, 2003, where it received routine maintenance, as well as upgrades and modifications recommended by the *Columbia* Accident Investigation Board.

NASA is complying with the recommendations of the *Columbia* Accident Investigation Board, as well as NASA-initiated "raise the bar" actions. NASA's *Implementation Plan for Space Shuttle Return to Flight and Beyond* documents the return to flight effort. The Plan is updated periodically to ensure that it accurately records the progress being made toward a safe return to flight.

A major aspect of the return to flight effort has been to address the technical, organizational, and procedural issues that led to the *Columbia* accident. This year, Space Shuttle program officials increased their understanding of the debris environment and the material characteristics of the orbiter and its Thermal Protection System. As a result, NASA has targeted critical areas for orbiter hardening prior to return to flight. To facilitate on-orbit inspections of areas of the Shuttle that are not visible using just the Shuttle Remote Manipulator System, NASA is installing a newly-developed Orbiter Boom Sensor System to inspect critical areas of the Shuttle's exterior. NASA also is developing viable repair techniques and materials for the Thermal Protection System, and the Agency made progress in developing materials and procedures for repairing tile and reinforced

Carbon-Carbon in flight. The Space Shuttle and International Space Station programs also have made progress in defining and planning for a Contingency Shuttle Crew Support capability to sustain a Shuttle crew on the International Space Station if a rescue mission is ever needed.

The Stafford-Covey Task Group assessed NASA's implementation of the Columbia Accident Investigation Board's return to flight recommendations and other technical issues and conditionally closed five of the Board's 15 return to flight recommendations.

The following table shows all 15 return to flight recommendations of the Columbia Accident Investigation Board and NASA's compliance status as of September 30, 2004.

CAIB RTF Recommendations		NASA Response	Status
3.2-1	Initiate an aggressive program to eliminate all External Tank Thermal Protection System debris-shedding at the source with particular emphasis on the region where the bipod struts attach to the External Tank.	NASA has completed several assessments of debris sources and sizes from the External Tank. A comprehensive testing program to understand the root causes of foam shedding is nearly complete. Bipod Ramp and LO2 Feedline Bellows drip lip redesigns are complete and going through validation and verification.	In Work
3.3-2	Initiate a program designed to increase the Orbiter's ability to sustain minor debris damage by measures such as improved impact-resistant Reinforced Carbon-Carbon and acreage tiles. This program should determine the actual impact resistance of current materials and the effect of likely debris strikes.	NASA has initiated an Orbiter hardening program to increase the Orbiter's capability to sustain minor debris damage. NASA identified 8 different design families and then grouped work into 3 categories based on when work should be completed. All Phase I or RTF requirements will be implemented before RTF. These included front spar protection on the wings RCC panels, main landing gear door thermal barrier protection and elimination of bonded studs from the Forward Reaction Control System. Other modifications are underway.	In Work
3.3-1	Develop and implement a comprehensive inspection plan to determine the structural integrity of all Reinforced Carbon-Carbon system components. This inspection plan should take advantage of advanced non-destructive inspection technology.	The Space Shuttle program is pursuing inspection capability improvements using newer technologies to allow comprehensive nondestructive inspection of the Reinforced Carbon-Carbon outer coating and internal structure, and without removing it from the vehicle.	Conditionally closed by Stafford-Covey Task Group
3.4-1	Upgrade the imaging system to be capable of providing a minimum of three useful views of the Space Shuttle from liftoff to at least Solid Rocket Booster separation, along any expected ascent azimuth. The operational status or these assets should be included in the Launch Commit Criteria for future launches. Consider using ships or aircraft to provide additional views or the Shuttle during ascent.	NASA has increased the total number of ground cameras and added additional short-, medium-, and long-range camera sites. NASA has approved the development and implementation of an aircraft-based imaging system known as the WB-57 Ascent Video Experiment (WAVE) to provide both ascent and entry imagery. NASA is optimizing launch requirements to support the ability to capture three complementary views of the Shuttle and adding launch commit criteria to assure imaging capabilities for critical control systems and data collection nodes. NASA has also confirmed that existing launch requirements relating to weather constraints support camera coverage requirements.	In Work
3.4-2	Provide a capability to obtain and downlink high-resolution images of the External Tank after it separates.	NASA is completing test and verification of the performance of a new digital camera in the Orbiter's umbilical well. Orbiter design engineering and modifications to provide this capability are underway on all three vehicles.	In Work
3.4-3	Provide a capability to obtain and downlink high-resolution images of the underside on the Orbiter wing leading edge and forward section of both wings' Thermal Protection System.	For the first few missions, NASA will use primarily on-orbit inspections to meet the requirement to assess the health and status of the Orbiter's TPS. This will be accomplished by using a number of imagery sources including cameras on the External Tank and Solid Rocket Boosters. NASA's long-term strategy will include improving on-vehicle ascent imagery and the addition of an impact detection sensor system on the Orbiter.	In Work
4.2-1	Test and qualify the flight hardware bolt catchers.	NASA has completed the redesign of the bolt catcher assembly, the redesign and resizing of the ET attachment bolts and inserts, the testing to characterize the energy absorber material, and the testing to determine the design loads. NASA is completing structural and thermal protection material qualification testing.	In Work

CAIB RTF Recommendations		NASA Response	Status
4.2-3	Require that at least two employees attend all final closeouts and intertank area hand-spraying procedures.	NASA has established a TPS verification team to verify and validate all future foam processes. In addition, the Material Processing Plan will define how each specific part closeout on the External Tank will be processed. Additionally, the Shuttle Program is documenting the requirement for minimum two-person closeouts for all major flight hardware elements (Orbiter, External Tank, Solid Rocket Booster, Solid Rocket Motor, extravehicular activity, vehicle processing, and main engine).	Conditionally closed by Stafford-Covey Task Group
4.2-5	Kennedy Space Center Quality Assurance and United Space Alliance must return to the straightforward, industry-standard definition of "Foreign Object Debris" and eliminate any alternate or statistically deceptive definitions like "processing debris."	The Kennedy Space Center has completed work to establish a revitalized program for identifying and preventing foreign object debris that surpasses the CAIB's recommendation.	Conditionally closed by Stafford-Covey Task Group
6.2-1	Adopt and maintain a Shuttle flight schedule that is consistent with available resources. Although schedule deadlines are an important management tool, those deadlines must be regularly evaluated to ensure that any additional risk incurred to meet the schedule is recognized, understood, and acceptable.	NASA is developing a process for Shuttle launch schedules that incorporates all of the manifest constraints and allows adequate margin to accommodate a normalized amount of changes. This process entails building in launch margin, cargo and logistics margin, and crew timeline margin. The Shuttle program is examining the risk management process and tools that assess technical, schedule, and programmatic risks. Risk data will be displayed on the One-NASA Management Information System. Senior managers can virtually review schedule performance indicators and risk assessments on a real-time basis.	In Work
6.3-1	Implement an expanded training program in which the mission Management Team faces potential crew and vehicle safety contingencies beyond launch and ascent.	NASA's response is being implemented in two steps: 1) review and revise Mission Management Team processes and procedures; and 2) develop and implement a training program consistent with those process revisions. Both of these activities are in work.	In Work
6.3-2	Modify the Memorandum of Agreement with the National Imagery and Mapping Agency to make the imaging of each Shuttle flight while on orbit a standard requirement.	NASA has concluded a Memorandum of Agreement with the National Imagery and Mapping Agency (subsequently renamed the National Geospatial-Intelligence Agency) and has initiated discussions with other agencies to explore the use of appropriate national assets to provide for on-orbit assessments of the condition of each Orbiter vehicle.	Conditionally closed by Stafford-Covey Task Group

6.4-1	For missions to the International Space Station, develop a practicable capability to inspect and effect emergency repairs to the widest possible range of damage to the Thermal Protection System, including both tile and Reinforced Carbon-Carbon, taking advantage of the additional capabilities available when near to or docked at the International Space Station. For non-Station missions, develop a comprehensive autonomous (independent of Station) inspection and repair capability to cover the widest possible range of damage scenarios. Accomplish an on-orbit Thermal Protection System inspection, using appropriate assets and capabilities, early in all missions. The ultimate objective should be fully autonomous capability for all missions to address the possibility that an International Space Station mission fails to achieve the correct orbit, fails to dock successfully, or is damaged during or after undocking.	Thermal Protection System (TPS) inspection and repair represent one of the most challenging and extensive RTF tasks. NASA has defined preliminary inspection requirements. Testing and analyses continue to determine the best sensors to detect TPS damage. The Reinforced Carbon-Carbon (RCC) repair project is pursuing two complementary repair concepts that together will enable repair of RCC damage: Plug Repair and Crack Repair. NASA has made significant progress in developing tile repair processes and repair material. Detailed thermal analyses and testing are underway to confirm the material can be applied and cured in the full range of orbit conditions. NASA is also developing EVA tools and techniques for TPS repair. Experiences gained through complex International Space Station construction tasks are contributing to NASA's ability to meet this challenge. In addition to planned TPS repair capability, special on-orbit tests are under consideration for STS-114 to further evaluate TPS repair materials, tools, and techniques.	In Work
9.1-1	Prepare a detailed plan for defining, establishing, transitioning, and implementing an independent Technical Engineering Authority, independent safety program and a reorganized Space Shuttle Integration Office.	Although the CAIB recommendation only requires preparation of a detailed plan prior to return to flight, NASA concluded that this important issue requires prompt implementation. Planning for these organizational changes is underway.	In Work
10.3-1	Develop an interim program of closeout photographs for all critical sub-systems that differ from engineering drawings. Digitize the closeout photograph system so that images are immediately available for on-orbit troubleshooting.	NASA has also created a robust system for photographing, archiving, and accessing closeout photography for the Space Shuttle. This system will allow key users across the Agency to quickly and easily access images of the Shuttle systems to make operational decisions during a mission and support postflight assessments.	Conditionally closed by Stafford-Covey Task Group

Performance Measures for Objective 8.3		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 8.3.1	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		Outcomes originated in FY 2004		
APG 4SSP1	Implement necessary modifications to the Space Shuttle system for return-to-flight in FY 2004.	yellow		3H05 red	2H6 green	1H7 green
APG 4SSP2	Achieve zero Type-A (damage to property at least $1M or death) or Type-B (damage to property at least $250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY 2004.	yellow		3H06 red	2H7 green	1H30 green
APG 4SSP3	Achieve 100% on-orbit mission success for all Shuttle missions launched in FY 2004. For this metric, mission success criteria are those provided to the prime contractor (SFOC) for purposes of determining successful accomplishment of the performance incentive fees in the contract.	white		3H08 green	2H09 green	1H6 yellow

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 8
Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.

OBJECTIVE 8.4

Assure capabilities for world-class research on a laboratory in low Earth orbit.

WHY PURSUE OBJECTIVE 8.4?

When completed, the International Space Station will include more space for research than any spacecraft ever built. It accommodates public- and private-sector research in biological and physical sciences, Earth and space observations, and technology development. It also houses research that will make future human space exploration possible.

Figure 129: Expedition crewmember Edward M. (Mike) Fincke conducts one of several tests for the Capillary Flow Experiment in the Destiny Laboratory on September 18, 2004.

Working with its international partners, NASA is managing resources to maximize the research potential on the Station, including optimizing the crew size in the near and long term.

When the Shuttle fleet returns to flight, NASA will resume International Space Station construction. The Agency also will deliver research facilities to the Station, like the second Human Research Facility, as well as a full complement of research payloads to get the Station back up to full research capacity. In addition, NASA is exploring new ways to enhance Station research, such as analyzing whether the Shuttles can be modified to provide extended Station stays to enable additional research capabilities.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 8.4.1: Provide a safe, reliable, and well-managed on-orbit research facility.
The International Space Station Program has provided a safe, reliable, and well-managed on-orbit research facility. On July 23, 2004, the International Partners revised the baseline for the Station's Assembly and endorsed the Multilateral Coordination Board-recommended configuration. The Station partners are working on plans to provide the services necessary to support the Station's crew and cargo transportation. The Shuttle's return to flight is scheduled for no earlier than May 2005.

Figure 130: Expedition 8 Flight Engineer Alexander Y. Kaleri performs maintenance on the Treadmill Vibration Isolation System in the Zveda Service Module on November 23, 2003.

In FY 2004, there were no Type-A mishaps (an occurrence or event that causes death or damages to equipment or property equaling to $1 million or more). There was one Type-B mishap on the ground at a sub-contractor facility in October 2003. (A Type-B mishap is an occurrence or event that causes permanent disability, hospitalizes three or more people, or causes damage to equipment or property equal to or greater than $250,000, but less than $1 million.) A spare cupola window was crushed at the Dow Corning plant. Although damage was estimated at $300,000, there were no injuries. The final mishap investigation report is in concurrence.

Since the Space Shuttle was grounded in February 2003, the planned science activities have been limited by the reduced crew size and transport capabilities of the Russian Progress and Soyuz spacecraft. However, NASA minimized the impact of these limitations by re-planning and rescheduling science activities, and, as a result, the Expedition 8 crew conducted 276 hours of research, operating 138 percent of the re-planned investigations. The crew initiated four new investigations and continued 18 investigations.

In FY 2004, overall International Space Station systems performance surpassed expectations in light of the grounding of the Space Shuttle fleet. For example, the International Space Station crew was able to repair the Treadmill Vibration Isolation System gyro on-orbit instead of returning it to Earth for repairs. In addition, the crews completed two-person extravehicular activities safely and successfully without a crewmember inside the Station.

If NASA is to fulfill the Vision for Space Exploration, a vision that depends on full utilization of the Station's facilities and capabilities, contingency plans for Station logistics and maintenance services are critical. NASA and the Agency's international partners have learned a great deal functioning with a crew of two persons, lessons that will enable realistic contingency planning and enhance future exploration initiatives.

Outcome 8.4.2: Expand the ISS crew size to accommodate U.S. and International Partner research requirements.
The international partnership, through a Multilateral Program Partner Team reporting directly to the Multilateral Coordination Board, evaluated options for the International Space Station on-orbit configuration. This team principally explored options related to accommodating a crew greater than three and the associated advanced life support systems, habitability elements, and rescue vehicles necessary to meet utilization mission requirements for an increased crew size. The Heads of Agency endorsed the Board-recommended Station configuration on July 23, 2004, a configuration that will accommodate a larger on-orbit crew.

Performance Measures for Objective 8.4		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 8.4.1	Provide a safe, reliable, and well-managed on-orbit research facility.	green		Outcomes originated in FY 2004		
APG 4ISS2	Achieve zero Type-A (damage to property at least $1M or death) or Type-B (damage to property at least $250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY 2004.	yellow		3H11 green	2H10 green	none
APG 4ISS3	Based on the Space Shuttle return-to-flight plan, establish a revised baseline for ISS assembly (through International Core Complete) and research support.	green		3H02 yellow	none	none
APG 4ISS4	Provide at least 80% of up-mass, volume and crew-time for science as planned at the beginning of FY 2004.	green		none	none	none
Outcome 8.4.2	Expand the ISS crew size to accommodate U.S. and International Partner research requirements.	green		Outcomes originated in FY 2004		
APG 4ISS5	Obtain agreement among the International Partners on the final ISS configuration.	green		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Goal 8
Ensure the provision of space access, and improve it by increasing safety, reliability, and affordability.

OBJECTIVE 8.5

Provide services for space communications, rocket propulsion testing, and launch in support of NASA, other government agencies and industry.

WHY PURSUE OBJECTIVE 8.5?

Safe and successful space flight relies on a variety of technologies and support services, including communication networks, rocket test facilities, and launch services. Dependable communications

Figure 131: A 750,000 pound-thrust rocket engine undergoes a test firing at Marshall Space Flight Center.

are vital to the success of all human and robotic space missions. Mission controllers, astronauts, and scientists depend on communications networks to monitor spacecraft, intercede when problems arise, and share technical and scientific data. NASA continuously improves the Agency's space communications networks to increase compatibility among network nodes and streamline current and projected requirements for network connectivity, security, and manageability. NASA, in cooperation with other government agencies, is developing space communication architectures to meet the needs of future exploration.

NASA also operates, maintains, and enhances test facilities to test rocket engines and engine components used in current flight vehicles and future rocket propulsion technologies and systems. These facilities are available to NASA researchers, other government agencies, and industry.

In addition, NASA will continue to work with government and industry partners to ensure that resources are available to meet the Nation's space launch needs. NASA ensures that its internal customers, as well as its government and commercial customers, have access to all available launch services, including the Space Shuttle, commercial and Department of Defense launch vehicles, and foreign launch services.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 8.5.1: Provide safe, well-managed and 95% reliable space communications, rocket propulsion testing, and launch services to meet agency requirements.

Space Communications

Reliable and consistent space communications are critical for the success of any mission outside of Earth's gravity. Without it, astronauts and cosmonauts onboard the International Space Station would be unable to communicate with Earth and to retrieve and send scientific data to researchers. NASA's Space Network is the primary source of connectivity for the Station and Space Shuttle. If, for any reason, this network should become unavailable, the Russian network can provide communications only while the space vehicles are over Russia. The Space Network and NASA Integrated Services Network have continuously provided superb connectivity for all customers, and the connectivity proficiency of both networks consistently has exceeded 99 percent. The Space Network serves a number of science missions including Aqua, Aura, Gravity Probe-B, the Hubble Space Telescope, and Terra. The success of future missions to the Moon and Mars will rely on this same exceptional level of space communications support. To meet the communications requirements of the Vision for Space Exploration, NASA created the Space Communications Architecture Working Group, which will be responsible for establishing the NASA-wide baseline space communications architecture, including a framework for possible deep-space and near-Earth laser communications services.

Rocket Propulsion

NASA tests rocket propulsion and flight certifies rocket propulsion systems for the Space Shuttle and future generations of space vehicles. All Space Shuttle Main Engines must pass a series of test firings prior to being installed in the back of the orbiter. The Rocket Propulsion Testing program at the Stennis Space Center provides propulsion testing for the Marshall Space Flight Center in Huntsville, Alabama, the White Sands Test Facility near Las Cruces, New Mexico, and others. All Rocket Propulsion Testing Program customers indicated a positive assessment of the support provided by the program in surveys conducted during the past year. The Rocket Propulsion Testing Program managed this level of support while maintaining an excellent record of zero Type-A or Type-B mishaps in FY 2004.

Program successes in FY 2004 included enabling the Space Shuttle Main Engine to surpass a remarkable level of one million seconds of successful test and launch firings.

Another major highlight in FY 2004 occurred on October 23, 2003, when Space Shuttle Program contractor ATK Thiokol Propulsion successfully conducted the first static test firing of a five-segment Space Shuttle Reusable Solid Rocket Motor. The test was part of an ongoing safety program to verify material and manufacturing processes. The five-segment motor pushed various features of the motor to their limits so engineers could validate the safety margins of the four-segment motors currently used to launch the Space Shuttle. The new five-segment motor has about a ten-percent-greater capability than the four-segment motor and could increase the Space Shuttle's payload capacity by 23,000 pounds.

Launch services

In the area of launch services for NASA's robotic space science research missions, NASA facilitated the successful launch of three science research missions in FY 2004—a 100 percent success rate for missions on the FY 2004 Expendable Launch Vehicle manifest. The three missions were as follows:

Figure 132: A Delta II rocket, carrying the MESSENGER spacecraft, waits on the launch pad at Kennedy Space Center on August 2, 2004, after its early-morning launch was scrubbed due to weather. The rocket and its spacecraft passenger successfully launched the next morning around 2:15 am EDT.

- Gravity Probe B, successfully launched on April 20, 2004, will answer questions raised about Einstein's General Theory of Relativity;
- Aura, part of the Earth Observing System, successfully launched on July 15, 2004, on a mission to study Earth's climate change and air quality; and
- The MESSENGER spacecraft, successfully launched on August 3, 2004, will travel over the next 6.5 years to the innermost planet of our solar system, Mercury, where it will study the planet's geography and climate to understand its history and significance in the solar system.

All three missions were launched using Boeing Delta II rockets, acquired commercially through NASA launch services contracts. The Launch Services Program is committed to providing assured access to space for NASA's robotic science missions and to enabling the continued exploration of the solar system. These activities, vital to the Agency's mission, would not be possible without consistently superior launch services. NASA's Launch Services Program partners with other Federal agencies, including the United States Air Force and the Federal Aviation Administration, to ensure that customers have access to space and that range safety is a high priority.

Performance Measures for Objective 8.5		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 8.5.1	Provide safe, well-managed and 95% reliable space communications, rocket propulsion testing, and launch services to meet Agency requirements.	green		Outcomes originated in FY 2004		
APG 4SFS4	Maintain NASA success rate at or above a running average of 95% for missions on the FY 2004 expendable launch vehicle (ELV) manifest.	green		3H03 blue	2H3 green	none
APG 4SFS5	Achieve at least 95% of planned data delivery for the International Space Station, each Space Shuttle mission, and low Earth orbiting missions in FY 2004.	blue		3H14 blue	none	none
APG 4SFS6	Achieve zero Type-A (damage to property at least $1M or death) or Type-B (damage to property at least $250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY2004.	green		3H04 blue	none	none
APG 4SFS7	Achieve positive feedback from a minimum of 95% of all rocket propulsion test customers.	green		none	none	none
APG 4SFS8	Establish the Agency-wide baseline space communications architecture, including a framework for possible deep space and near-Earth laser communications services.	green		none	none	none

Goal 9
Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.

OBJECTIVE 9.1

Understand human physiological reactions to reduced gravity and develop countermeasures to assure survival of humans traveling far from Earth.

WHY PURSUE OBJECTIVE 9.1?

For over 40 years, NASA has been sending astronauts into space, and during this time, researchers have sought to understand gravity in the physical universe and its impact on life. Scientists now understand that biological systems undergo changes during short- and long-term space travel—changes that still are not fully understood. Researchers do know that some of the physiological changes that occur in microgravity are not problematic during space flight, but are potentially risky upon return to Earth or another gravitational environment, like the surface of Mars. Therefore, humankind's eventual long-term travel beyond Earth's orbit requires further research to fully explain these changes and prepare explorers for the challenges and risks they will face in new space environments.

Figure 133: Expedition 8 crewmember Michael Foale runs on the Treadmill Vibration Isolation System, with the help of a bungee harness, in the Zveda Service Module on April 12, 2004. The crew has a variety of exercise equipment to help them prevent some of the muscle loss that occurs in the near-weightlessness (also called microgravity) of Earth orbit.

NASA is conducting ground- and space-based research to identify and mitigate the changes that occur to the body—like bone loss, muscle atrophy, and changes to the cardiovascular and sensory systems—in various gravitational environments. The International Space Station is serving as a platform to study these changes over long periods and to test medications and technologies that could serve as countermeasures.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 9.1.1: By 2008, develop and test candidate countermeasures using ground-based analysis and space flight.

To prepare astronauts for the rigors of space travel, NASA provides medical preparation, protection from the hazards of space travel, and methods to help them stay fit and improve their performance while in space. NASA does this by researching critical health and safety risks, developing solutions to enable informed decision-making, and maintaining a Critical Path Roadmap to guide research priorities for human space flight. Currently funded research experiments include Dr. Nick Kanas's "Crewmember and Crew–Ground Interactions During International Space Station Missions," which addresses human performance, interpersonal relationships, team cohesiveness, and group dynamics during long missions (Critical Risk #27). This research helped NASA improve crew training programs and support services the Agency provides to crews during missions. Dr. Peggy Whitson's "Renal Stone Risk During Space Flight: Assessment and Countermeasure Validation" experiment is testing the use of potassium citrate to combat astronauts' increased risk of renal stones due to bone loss and reduced fluid volume in the body during flight, resulting in higher amounts of calcium in urine (Critical Risk #4). Dr. Peter Cavanagh's "Foot Reaction Forces During Space Flight" experiment examines the bone and muscle loss that occur when the body does not bear weight and the degree to which in-flight exercise, NASA's primary

Figure 1345: Astronaut C. Michael Foale (center) and cosmonaut Alexander Y. Kaleri (right) receive training for the Advanced Diagnostic Ultrasound in Microgravity experiment from instructor Ashot Sargsyan on August 18, 2003, in preparation for their participation in International Space Station Expedition 8.

countermeasure for this problem, helps reduce these losses (Critical Risks #20 and #22). Although scientists have conducted a great deal of research on bone loss and muscle atrophy during space flight, "Foot" is the first experiment to quantify the amount of load placed on limbs in microgravity. Dr. Scott Dulchavsky's "Advanced Ultrasonic Diagnosis in Microgravity" experiment tested the use of an ultrasound device onboard the International Space Station to help crewmembers diagnose various medical conditions either on their own or by telemedicine (a process in which a medical professional provides remote assistance using the Internet or radio transmission; Critical Risks #20 and #22). This research will help NASA ensure that crews can care for themselves during long-duration space exploration beyond low Earth orbit. NASA researchers working on Critical Risk #22, which addresses ambulatory care, the diagnosis and management of minor illnesses, management of minor trauma, also published 62 articles and abstracts discussing their findings in FY 2004.

NASA also evaluated the results of biomedical and space medicine research to determine potential applications on Earth. Researchers at the Johnson Space Center recently identified a potential relationship between radiation exposure and cataract formation. This information is beneficial to NASA, as well as to military and civilian aviation medicine. The experiences of those living on the International Space Station helps NASA better understand the effect of space on the human body and the effect of isolation on human behavior and performance. The Station also provides a place to test advanced emergency life-support systems, clinical and surgical capabilities, and astronauts' nutrition requirements as NASA works to meet the Vision for Space Exploration.

Outcome 9.1.2: By 2008, reduce uncertainties in estimating radiation risks by one-half.

Sixty-eight principal investigators used NASA's Space Radiation Laboratory at Brookhaven National Laboratory, one of the few places in the world that can simulate the harsh cosmic and solar radiation environment found in space. This achievement exceeded the annual performance goal of 50 investigators by 18, or 36 percent. NASA also held multiple workshops in FY 2004, including the Third International Workshop on Space Radiation Research, held May 15–20, 2004. And, NASA completed two NASA Space Radiation Laboratory runs in FY 2004: one in the fall and one in the spring, in addition to the commissioning run. The NASA Space Radiation Laboratory became operational in October 2003. Actual

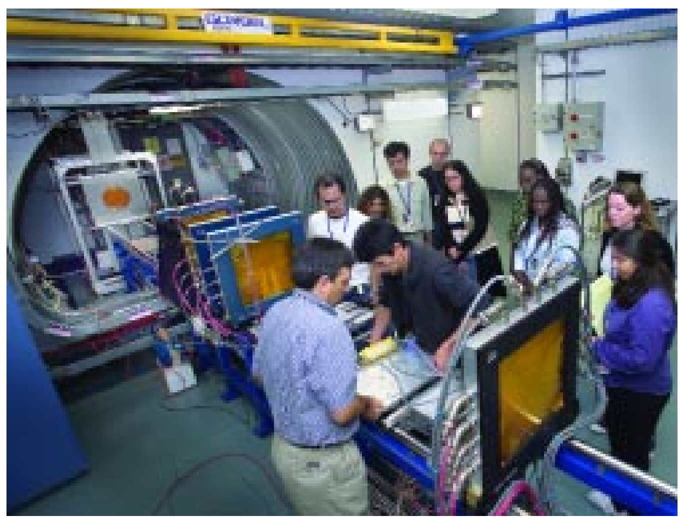


Figure 135: Students stand in the target area at the NASA Space Radiation Laboratory.

research beam use totaled 838 hours in the first contract year exceeding the projected 650 hours for FY 2004 by 188 hours, or 29 percent. NASA continues to study cataract risks through research that evaluates astronaut radiation exposure.

Outcome 9.1.3: Advance understanding of the role of gravity in biological processes to support biomedical research.
NASA made satisfactory progress towards achieving this Outcome by soliciting help from the greater research community in a variety of disciplines. Examples of these solicitations include: "Research Opportunities Soliciting Ground Based Studies for Human Health in Space" and "NASA Research Announcement for Flight Experiments in Space Life Sciences." NASA launched the "Yeast Gap" experiment on a Progress in January 2004, and astronauts on-board the International Space Station conducted related experiment activities in February 2004. NASA also launched the International *C. elegans* Experiment to the International Space Station on May 19, 2004, a collaborative experiment involving the United States, France, Japan, and Canada. Researchers are analyzing the returned data.

Performance Measures for Objective 9.1		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 9.1.1	By 2008, develop and test candidate countermeasures using ground-based analysis and space flight.	green		Outcomes originated in FY 2004		
APG 4BSR8	Use ground-based and space-based research to lessen the risks related to long duration phenomena such as bone loss, physiological adaptation to isolation and confinement, and the biological effects of radiation as described in the Bioastronautics Critical Path Roadmap.	green		3B1 green	2B1 green	none
APG 4BSR9	Publish results of Bioastronautics experiments conducted during early ISS Increments (1 through 8) and preliminary results from Increments 9 and 10.	green		none	none	none
APG 4BSR10	Maintain productive peer-reviewed research program in Biomedical Research and Countermeasures, including a National Space Biomedical Research Institute that will perform team-based focused countermeasure-development research.	green		none	none	none
APG 4SFS10	Certify the medical fitness of all crew members before launch.	green		none	none	none
Outcome 9.1.2	By 2008, reduce uncertainties in estimating radiation risks by one-half.	blue		Outcomes originated in FY 2004		
APG 4BSR11	Expand the space radiation research science community to involve cutting edge researchers in related disciplines by soliciting, selecting, and funding high quality research.	green		none	none	none
APG 4BSR12	Complete two experimental campaigns ("runs") using recently completed National Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory (BNL) to measure survival, genetic mutation (mutagenesis), and chromosome aberrations in cells and tissues to improve understanding of the biological effects of the space radiation environment.	green		none	none	none
APG 4BSR13	Evaluate radiation risks to astronauts by continued and careful analysis of past radiation exposures, results of medical follow up, and comparison with appropriately chosen control population not exposed to similar levels of radiation. Make experimental data available for operational use on ISS and other space-realted activities where appropriate.	green		none	none	none
Outcome 9.1.3	Advance understanding of the role of gravity in biological processes to support biomedical research.	green		Outcomes originated in FY 2004		
APG 4BSR14	Openly solicit ground-based research in appropriate Fundamental Biology disciplines to lay the ground work for advanced understanding of the role of gravity in biological processes associated with the human health risks of space flight.	green		none	none	none
APG 4BSR15	Plan for increased early utilization for basic biology research in 2005 to take advantage of evolving ISS capabilities.	green		none	none	none
APG 4BSR16	Maintain a competitive, productive peer-reviewed research program to advance understanding of the role of gravity in biological processes.	green		none	none	none

Goal 9
Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.

OBJECTIVE 9.2

Develop new human support systems and solutions to low gravity technological challenges to allow the next generation of explorers to go beyond low Earth orbit.

WHY PURSUE OBJECTIVE 9.2?

As humans embark on missions of greater duration and distance, NASA must extend its current technological capabilities to achieve greater autonomy, efficiency, reliability, and safety and security in low-gravity environments. This includes enhancing life support systems to maintain an environment and resources—air, water, food, thermal heat, and energy—that will sustain and protect human health and safety during all phases of a mission, including utilizing available resources efficiently at their destination.

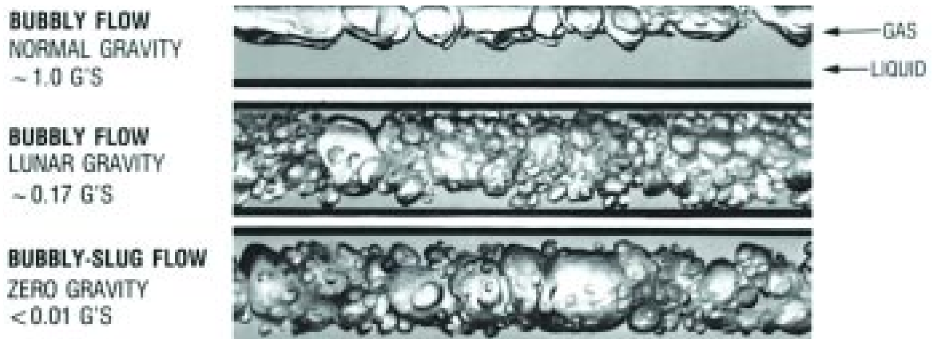


Figure 136: The flow of gas and liquid mixtures, such as steam and water, is strongly affected by gravity. In this picture air–water mixtures are shown at the same flow rates under different gravity levels. NASA researchers must study the phenomena that affect air–water mixtures before engineers can design devices, such as heating or water filtration systems, for use in space.

NASA uses laboratories, analog environments like undersea habitat training facilities, and simulators to develop, test, and verify technologies for advanced space missions. NASA's partners from universities, the private sector, and other government agencies contribute to all phases of research and technology development, including the initial development of concepts, prototype development and testing, fabrication, and final verification. NASA also uses a number of facilities to flight validate technologies, including parabolic flight facilities like the KC-135, drop towers, free flyers, and most important, the International Space Station.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 9.2.1: Identify and test technologies by 2010 to reduce total mass requirements by a factor of three for Life Support using current ISS mass requirement baseline.

NASA made satisfactory progress toward this Outcome during FY 2004. Since 1999, NASA has tracked an advanced life-support metric, and the Agency has achieved a 50-percent reduction in the estimated mass of a life-support system using current technologies compared to the Station's system baselines. The FY 2004 advanced life-support metric showed a moderate increase over FY 2003. First, the dry food mass from both numerator and denominator in the metric calculation was deleted, since the amount of dry food humans need is a fixed quantity. Second, NASA made systems engineering improvements in atmosphere air storage by using cryogenic storage instead of the high-pressure tanks used in the past. Another technology that helped raise the metric is the Vapor Phase Catalytic Ammonia Removal system that represents the next generation in space flight water recovery systems. NASA's Mobile Intelligent Vehicle Health Management System, also known as the Personal Satellite Assistant, provides additional eyes, ears, and other sensory input for astronauts performing internal tasks. The system testbed is now complete, and NASA completed a demonstration of its capability at the end of September.

Outcome 9.2.2: By 2008, develop predictive models for prototype two-phase flow and phase change heat transfer systems for low- and fractional gravity with an efficiency improvement of at least a factor of two over 2003 ISS radiative systems, and prepare ISS experiments for validation. NASA conducted two major studies to organize research content in multiphase fluid and thermal systems. One, on transport issues in human support systems, is documented in a NASA Technical Memorandum. The other, on engineering issues in fluid and thermal systems, was conducted by a group of nationally-recognized experts and resulted in a report that is in final review. This priority area for research support received one-half of the grant awards in the most recent fluid physics NASA Research Announcement, compared with a historical representation of one quarter to one third. International Space Station research payloads are under review, but significant research activity aboard the Station is still in development for this area.

Figure 137: NASA's Personal Satellite Assistant is an autonomous, free-floating robot equipped with sensors to monitor environmental conditions inside a spacecraft or other enclosed environment.

Outcome 9.2.3: By 2008, develop predictive engineering model and prototype systems to demonstrate the feasibility of deploying enhanced space radiation-shielding multi-functional structures with at least a factor of two improvement in shielding efficiency and mass reduction, and prepare a space experiment for validation.
The NASA Space Radiation Laboratory opened in October 2003 and is now fully operational. Acquisition of data on shielding material performance is now underway. NASA held a workshop in June 2004 to define requirements for Antarctic balloon-borne research on material interactions with energetic solar particles for the Deep Space Testbed project. The report recommended mission content and timelines. NASA released a NASA Research Announcement, including a call for proposals in radiation materials research, in late FY 2004. Budget uncertainties affected selection decisions, but they are expected shortly.

Performance Measures for Objective 9.2		2004 Rating	Past Years' Performance Measures and Ratings: 2003	2002	2001
Outcome 9.2.1	Identify and test technologies by 2010 to reduce total mass requirements by a factor of three for Life Support using current ISS mass requirement baseline.	green	Outcomes originated in FY 2004		
APG 4BSR17	Demonstrate, through vigorous research and technology development, a 50% reduction in the projected mass of a life support flight system compared to the system baselined for ISS.	green	3B2 green	2B2 green	none
APG 4HRT14	Demonstrate ground test of a Mobile Intelligent Vehicle Health Management (IVHM) system for internal spacecraft operations that will provide environmental sensing capabilities and knowledge management services. The Mobile IVHM will perform independent calibration checks for environmental sensors; autonomously replace or substitute for failed environmental sensors; hunt down and isolate gas leaks and temperature problems; and provide a range of crew personal data assistant functions.	green	none	none	none
Outcome 9.2.2	By 2008, develop predictive models for prototype two-phase flow and phase change heat transfer systems for low and fractional gravity with an efficiency improvement of at least a factor of two over 2003 ISS radiative systems, and prepare ISS experiments for validation.	blue	Outcomes originated in FY 2004		
APG 4PSR8	Increase the current strategic ground research in microgravity heat exchange and advance the existing ISS investigations toward flight.	green	none	none	none
Outcome 9.2.3	By 2008, develop predictive engineering model and prototype systems to demonstrate the feasibility of deploying enhanced space radiation-shielding multi-functional structures with at least a factor of two improvements in shielding efficiency and mass reduction, and prepare a space experiment for validation.	green	Outcomes originated in FY 2004		
APG 4PSR9	Extend the available database on radiation effects on materials properties using the newly commissioned NASA Space Radiation Laboratory at Brookhaven.	green	none	none	none

Goal 9
Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.

OBJECTIVE 9.3

Demonstrate the ability to support a permanent human presence in low Earth orbit as a stepping-stone to human presence beyond.

WHY PURSUE OBJECTIVE 9.3?

Before humans venture beyond the relative safety of low Earth orbit, NASA must be certain that crews are fully prepared. NASA's primary challenge is to move from largely open life support systems that require frequent resupply to closed systems that recycle air, water, and waste. Advanced life-support systems and subsystems must be developed based on a thorough understanding of the underlying biological and physical processes involved. The advanced systems must require less power, be highly reliable and autonomous, and be smaller and lighter than current systems.

Figure 138: With tools in hand, Expedition 8 Flight Engineer Alexander Y. Kaleri and Expedition 7 Flight Engineer and Science Officer Edward T. Lu pause from their work in the Station's Unity Node on October 26, 2003. There has been crew continuously aboard the Station since November 2000, gaining experience of how to live and work in space for extended periods of time.

The International Space Station is serving as the first step to long-duration human space exploration beyond low Earth orbit. The Station is being used to develop life support technologies and create better understanding of the effects of variable gravity and radiation on humans and systems. The Station also provides a platform on which to demonstrate important skills, and their supporting technologies, like in-space construction and manufacturing and autonomous health care. NASA will use the International Space Station to ensure that crews can remain safe and productive with little or no direct support from Earth.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 9.3.1: Develop experience in working and living in space by continuously supporting a crew on-board the ISS through 2016.

The International Space Station has been continuously crewed since November 2000 starting with Expedition 1. At the end of FY 2004, Expedition 9 was onboard the Station, and Expedition 10 arrived safely in October 2004. The Station is on the critical path to fulfilling the Vision for Space Exploration, serving as a testbed for technology demonstration and research in long-duration space exploration.

Performance Measures for Objective 9.3		2004 Rating		2003	2002	2001
Outcome 9.3.1	Develop experience in working and living in space by continuously supporting a crew on-board the ISS through 2016.	green		Outcomes originated in FY 2004		
APG 4ISS6	Continuously sustain a crew to conduct research aboard the ISS.	green		none	none	none

Goal 9
Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.

OBJECTIVE 9.4

Develop technologies to enable safe, affordable, effective and sustainable human-robotic exploration and discovery beyond low Earth orbit (LEO).

WHY PURSUE OBJECTIVE 9.4?

Future exploration missions beyond low Earth orbit will require coordinating the unique capabilities of humans and robots to maximize safety, affordability, effectiveness, and sustainability. Robotic explorers will be the trailblazers, gaining insight and critical information about new environments to reduce risk for human explorers. They also will work alongside human explorers, offering an extra set of "hands," performing potentially hazardous tasks, and providing sensors and capabilities beyond what humans can do on their own.

Figure 139: Astronaut Nancy Currie participates in a test with the Robonaut to evaluate human–robotic operations. The Robonaut is just one example of the types of robotic systems that will work alongside human explorers during future space missions.

Through directed investments and innovative partnerships, NASA is developing, maturing, and validating key technologies for human–robotic exploration, including sensor technologies, modular systems, computing capabilities, space communications and networking, and new power and propulsion systems that can be integrated into future missions. NASA also is establishing research and development requirements and roadmaps to help the Agency identify promising technologies and concepts and develop improved technologies for risk analysis to ensure mission success.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 9.4.1: Identify, develop, and validate human-robotic capabilities by 2015 required to support human-robotic lunar missions.

As part of the Vision for Space Exploration, NASA is researching capabilities for human–robotic lunar missions. In support of this activity, NASA published the *Human and Robotic Technology Formulation Plan* on July 29, 2004. The Plan provides the strategy, objectives, and key technical challenges for guiding exploration technology development. Technology development projects will be selected competitively in a strategy-to-task process governed by the Plan. NASA also approved a charter for the Operational Advisory Group of technologists and operators to prepare for the missions. And, NASA created a review process and integration team to select and award intramural and extramural Human and Robotic Technology awards; the Agency selected 50 intramural projects on August 1, 2004. NASA also issued a Broad Agency Announcement on

July 28, 2004, and evaluated over 3,700 notices of intent. Of the 498 full proposals invited, NASA will select about 100 proposals in November 2004.

Outcome 9.4.2: Identify and execute a research and development program to develop technologies by 2015 critical to support human-robotic lunar missions.
NASA held a pre-solicitation conference in June 2004 to familiarize industry with the requirements and process for the NASA Broad Agency Announcement in the area of Human and Robotic Technology. NASA also held a pre-proposal conference in July 2004 for the Human and Robotic Technology Systems-of-Systems Broad Agency Announcement initiating the extramural process.

Outcome 9.4.3: 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.
NASA's Project Prometheus is developing the technologies needed to enable expanded exploration via nuclear fission-based power and propulsion systems. The Prometheus team (NASA and the Department of Energy) worked this year to align activities and exploration priorities set forth in the Vision for Space Exploration. This process began with the development of the Jupiter Icy Moons Orbiter Level-1 requirements and is now transitioning into the evaluation of nuclear propulsion and vehicle systems technology roadmaps. Prometheus personnel initiated multi-center, multi-agency focused technology and systems development processes in support of future human and robotic exploration missions.

Outcome 9.4.4: Develop and deliver one new critical technology every two years in at least each of the following disciplines: in-space computing, space communications and networking, sensor technology, modular systems, and engineering risk analysis.
NASA developed the *Human and Robotic Technology Formulation Plan* to establish the spiral technology development process that will lead to the development and delivery of critical technologies required for the development of Exploration Systems. Per the plan's process, NASA held a pre-proposal conference for the Human and Robotic Technology Systems-of-Systems Broad Agency Announcement initiating the extramural process. The Broad Agency Announcement process solicits technology development proposals and will select the most promising technology development activities for the aforementioned disciplines. Upon selection, projects will be established with required funding to develop the critical technologies.

Performance Measures for Objective 9.4		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 9.4.1	Identify, develop, and validate human-robotic capabilities by 2015 required to support human–robotic lunar missions.	green		Outcomes originated in FY 2004		
APG 4HRT1	Formulate guidelines for a top-down strategy-to-task (STT) technology R&D planning process that will facilitate the development of human–robotic exploration systems requirement.	green		none	none	none
APG 4HRT2	Charter an Operational Advisory Group of technologists and operators to prepare for two systems-focused Quality Function Deployment (QFD) exercises that will take place in FY 2005.	green		none	none	none
APG 4HRT3	Charter a Technology Transition Team that will review candidate human–robotic exploration systems technologies, and provide detailed updates to human–robotic technology road maps.	green		none	none	none
Outcome 9.4.2	Identify and execute a research and development program to develop technologies by 2015 critical to support human-robotic lunar missions.	green		Outcomes originated in FY 2004		
APG 4HRT4	Conduct an "Industry Day" by mid-FY 2004 to communicate the Exploration Systems Enterprise vision and processes.	green		none	none	none
Outcome 9.4.3	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.	green		Outcomes originated in FY 2004		
APG 4HRT5	Review nuclear propulsion and vehicle systems technology roadmap for alignment with exploration priorities, particularly human-related system and safety requirements.	green		none	none	none
Outcome 9.4.4	Develop and deliver 1 new critical technology every 2 years in at least each of the following disciplines: in-space computing, space communications and networking, sensor technology, modular systems, and engineering risk analysis.	green		Outcomes originated in FY 2004		

Goal 9
Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.

OBJECTIVE 9.5

Develop crew transportation systems to enable exploration beyond low Earth orbit (LEO).

WHY PURSUE OBJECTIVE 9.5?

Current space transportation is inadequate for human space exploration beyond low Earth orbit. Future space vehicles need improved power and propulsion, better radiation protection, lighter materials, and increased mission flexibility. The Space Shuttle was designed primarily as a reusable vehicle to transport crews and small payloads that could be assembled into large systems in space, like the International Space Station.

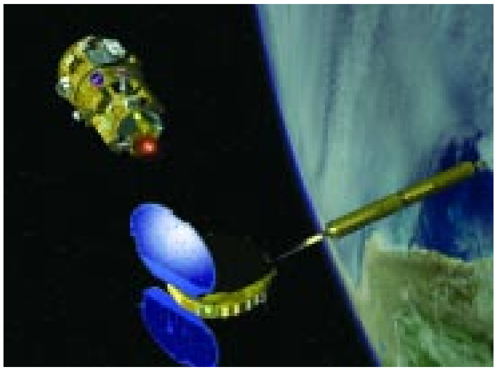


Figure 140: The Demonstration of Autonomous Rendezvous Technology (DART), shown here in an artist's concept rendezvousing with a target satellite, will develop and demonstrate key technologies for an autonomous approach to the International Space Station. DART is one of the building blocks for developing new crew transportation systems.

NASA has extended this modular "building block" approach as the conceptual foundation for creating the next generation of space transportation capabilities. The Agency is developing new crew transportation systems using an incremental approach that begins with an autonomous prototype that can evolve into a crew-rated vehicle. The major goal is to use affordable engineering practices and flexible designs that can be upgraded and altered to meet NASA's needs and take advantage of technology developments. NASA is leveraging its partnerships with other government agencies, industry, and academia to take advantage of advances in materials, power and propulsion, computing, and design. With its partners, NASA is conducting trade studies and other research to determine the best technology investments.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 9.5.1: 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 the Earth to destinations beyond LEO.

NASA made progress on the new Crew Transportation System as part of Project Constellation, a system of human and robotic spacecraft, launch vehicles, and lunar surface infrastructure required to get astronauts to and from the Moon and Mars. NASA is well into the planning process for the Crew Exploration Vehicle, the first element of this system. The Agency completed the acquisition strategy for the procurement of the Crew Exploration Vehicle and its associated launch vehicle. In addition, NASA selected 11 industry teams to work on the concept exploration and refinement effort for the vehicle. NASA continues to direct technology development efforts, which are beginning to bear fruit: the Demonstration of the Autonomous Rendezvous Technology program passed flight certification and is ready for launch from Vandenberg Air Force Base to demonstrate an autonomous rendezvous and docking capability. NASA also reviewed the Orbital Space Plane and Next Generation Launch Technology programs' lessons learned and is integrating these lessons into a risk management database to be used by the Project Constellation team to manage development of the Crew Transportation System.

Outcome 9.5.2: By 2010, identify and develop concepts and requirements that could support safe, affordable, and effective transportation and life support for human crews traveling from the Earth to the vicinity or the surface of Mars.

NASA defined requirements for supporting the safe transportation of humans to the vicinity and surface of Mars using a spiral development approach. The first spiral involves the definition of a Crew Exploration Vehicle for piloted launch in 2014. The second spiral will carry humans to the surface of the Moon and prove the equipment and techniques to be used in the later spirals to Mars. For future reference, NASA captured previous architecture and trade studies related to this effort in the Space Transportation Information Database at Marshall Space Flight Center. NASA also performed and catalogued new trade studies to help formulate requirements for the Crew Exploration Vehicle.

Performance Measures for Objective 9.5		2004 Rating	Past Years' Performance Measures and Ratings: 2003	2002	2001
Outcome 9.5.1	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	Outcomes originated in FY 2004		
APG 4TS1	The Demonstration of Autonomous Rendezvous Technology flight article will be certified for flight demonstration, establishing it as a test platform for demonstrating key technologies required to enable an autonomous (no pilot in the loop) approach to the International Space Station.	green	3SLI3 green	None	none
APG 4TS2	Conduct full reviews of OSP and NGLT programs, identifying acquisitions strategies, technologies, and lessons learned that are applicable to the new CEV program.	green	none	None	none
Outcome 9.5.2	By 2010, identify and develop concepts and requirements that could support safe, affordable, and effective transportation and life support for human crews traveling from the Earth to the vicinity or the surface of Mars.	green	Outcomes originated in FY 2004		
APG 4TS3	Compile a document that catalogs major architecture and engineering trade studies of space transportation architectures for human Mars exploration.	green	none	None	none

Goal 10 Enable revolutionary capabilities through new technology.

OBJECTIVE 10.1

Improve the capability to assess and manage risk in the synthesis of complex engineering systems.

WHY PURSUE OBJECTIVE 10.1?

Safety is one of NASA's core values. The safety of the public, NASA's people, and the Agency's major physical assets are of primary concern when NASA plans any mission or program. But to uphold this value, NASA recognizes that a certain amount of risk is inherent in any complex engineering system. A failure in a single subsystem can cause a cascade effect that may result in a mission not achieving some of its goals or failing completely. The key to mission success and safety is to identify potential failure points and devise ways to manage or avoid them early in mission development.

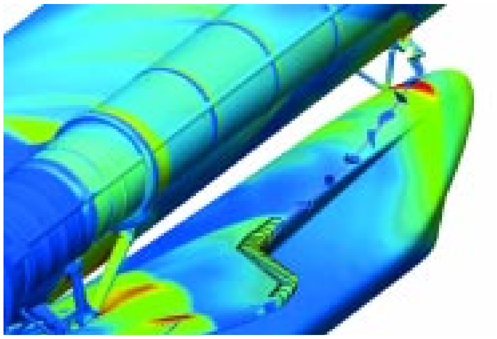


Figure 141: This image shows the computed trajectory (indicated by the pink line) of debris that damaged the wing of *Columbia* shortly after launch and ultimately caused its accident in February 2003. Computer modeling and simulation capabilities such as this can help to both investigate and analyze failures, as well as predict potential failures modes.

NASA is developing software tools that will help technologists and program planners analyze designs and organizational risks in subsystems, systems, and mission architectures. Such tools will allow planners to substitute components, subsystems, and systems and to identify trade-off capabilities between risks, as well as between risks and other mission design criteria. These risk assessment tools also will create a robust knowledge capture and communications process and increase a planner's ability to assess current status and implement successful risk control strategies. NASA also is designing software tools for accident investigation that will help scientists identify the causes of spacecraft, airplane, and other mission hardware accidents. Ultimately, all of NASA's risk assessment tools will allow planners to evaluate risks to humans and missions with the same fidelity and confidence that they now have in assessing standard parameters like cost, schedule, and performance.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 10.1.1: By 2005 demonstrate 2 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.

NASA developed prototypes of risk analysis tools to integrate capabilities for archiving, searching, visualizing, and investigating hazards. The Risk Tool Suite for Advanced Design aids users in considering a wide range of risk types (e.g., hardware, software, programmatic, organizational). The suite helps designers determine a number of optimal portfolios of project risks, costs, and mitigations, which they can analyze and use to guide them in choosing the best portfolio.

The Mishap and Anomaly Information System provides the capability to evaluate historical mishap and anomaly data for patterns, trends, and associated risks, then integrates this capability with the Risk Tool Suite to better utilize historical data to enhance early-phase design.

Through the fusion of accident investigation methodology with collaborative, information sharing technology, the Investigation Organizer tool has been used for multiple investigations, most recently by the overall Columbia Accident Investigation Board. In addition, the National Transportation Safety Board and other Federal agencies are evaluating this tool for their use, and it is being commercialized through a partnership with Xerox Corporation.

Performance Measures for Objective 10.1		2004 Rating		2003	2002	2001
Outcome 10.1.1	By 2005, demonstrate 2 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		Outcomes originated in FY 2004		
APG 4HRT7	Develop a Prototype Concept Design Risk Workstation that provides the capability to identify, track, and trade-off risk in the conceptual design phase of missions. The workstation will integrate databases, visualization modules, solicitation routines, system simulations, and analysis programs that support an interactive system design process.	green		3R11 green	none	none

Note: Objective 10.2 was cancelled.

Goal 10
Enable revolutionary capabilities through new technology.

OBJECTIVE 10.3

Leverage partnerships between NASA Enterprises, U.S. industrial firms, and the venture capital community for innovative technology development.

WHY PURSUE OBJECTIVE 10.3?

The ambitious task of safely returning humans to the Moon, and eventually sending human crews to Mars, cannot be accomplished by NASA alone. Achieving these goals will come only as a result of a team effort reflecting uncommon creativity and dedication, so NASA is working closely with other government agencies, industry, and academia partners to identify innovative ideas and pool resources. The Agency also is fostering even greater cooperation among its Mission

Figure 142: NASA will develop exploration technologies, like the vehicle shown in this artist's concept of lunar exploration, in cooperation with many internal and external partners.

Directorates to leverage most fully NASA's extraordinary science and technology competencies. Through directed investments and innovative partnerships, NASA will develop, mature, and validate advanced technologies and space operations concepts. These technologies will form the cornerstone of future exploration capabilities that are safe, affordable, effective, and sustainable.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 10.3.1: Promote and develop innovative technology partnerships between NASA, venture capital firms, and U.S. industry for the benefit of all Enterprise mission needs, initiating three partnerships per year.

In FY 2004, NASA signed 62 partnership agreements with industry. These agreements allow technology from outside NASA to be incorporated into NASA programs. NASA also made progress in the Agency's Enterprise Engine program. The Enterprise Engine will be managed according to commercial investment principles. To date, the partners have met with nearly 40 representatives from the venture and corporate venture communities, and they made presentations and/or served as panel members at relevant industry conventions. These activities generated significant interest and potential investment opportunities. In addition, the partnership team is in the process of hiring a law firm to assist in the establishment of a non-profit organization to act as NASA's agent for investment transactions—an identical operating model deployed by the Central Intelligence Agency with their In-Q-Tel venture capital arm. This new organization and its board of trustees should be in place by the start of 2005.

Outcome 10.3.2: Facilitate on an annual basis the award of venture capital funds or Phase III contracts to no less than two SBIR firms to further develop or produce their technology through industry or government agencies.

The NASA Alliance for Small Business Opportunity awarded venture capital funds to two firms: WaveBand Corporation and Tao of Systems Integration, Inc. WaveBand Corporation needed a flight test to validate product claims for prospective customers. The NASA Alliance team confirmed the commercialization potential of its autonomous landing radar system technology then shared the costs of a flight test with WaveBand. WaveBand now is competing on millions of dollars of contracts and has attracted private equity investment. The NASA Alliance also provided $30,000 to supplement WaveBand's funding of $70,000, to collect data through flight testing on a Cessna.

Tao of Systems Integration, Inc. invested ten years in the development of its robust flow characterization technology platform. The NASA Alliance team reviewed the commercialization potential then partnered with Tao to plan and execute a strategy. The team considered and ranked initial applications, adopted a marketing strategy, developed a business model, prepared a sequence of presentations, and made introductions to potential partners. Today, Tao is being considered for a licensing agreement, and Tao received a $60,000 contract from NASA's Dryden Flight Research Center to flight test a sensor. In addition, the Jet Propulsion Laboratory is testing one of Tao's instruments.

Performance Measures for Objective 10.3		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 10.3.1	Promote and develop innovative technology partnerships between NASA, venture capital firms and U.S. industry for the benefit of all Enterprise mission needs, initiating three (3) partnerships per year.	blue		Outcomes originated in FY 2004		
APG 4HRT8	Establish 3 partnerships with U.S. industry and the investment community using the Enterprise Engine concept.	yellow		none	none	none
APG 4HRT9	Develop 36 industry partnerships that will add value to NASA Enterprises.	blue		none	none	none
Outcome 10.3.2	Facilitate on an annual basis the award of venture capital funds or Phase III contracts to no less than two (2) SBIR firms to further develop or produce their technology through industry or government agencies.	green		Outcomes originated in FY 2004		
APG 4HRT10	Achieve through NASBO, the award of Phase III contracts or venture capital funds to 2 SBIR firms to further develop or produce their technology through industry or government agencies.	green		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Note: Objective 10.4 was cancelled.

Goal 10 Enable revolutionary capabilities through new technology.

OBJECTIVE 10.5

Create novel aeronautics concepts and technology to support science missions and terrestrial and space applications.

WHY PURSUE OBJECTIVE 10.5?

NASA uses its unique capabilities to develop advanced concepts and technologies that are critical to the future of aeronautics. Among these technologies are those for autonomous flight, especially at very high altitudes and for very long durations. NASA is partnered with the Federal Aviation Administration, the Department of Defense, and industry to guide uncrewed aerial vehicle development. The partnerships' goal is to enable routine, long-endurance operation in the national airspace above 18,000 feet.

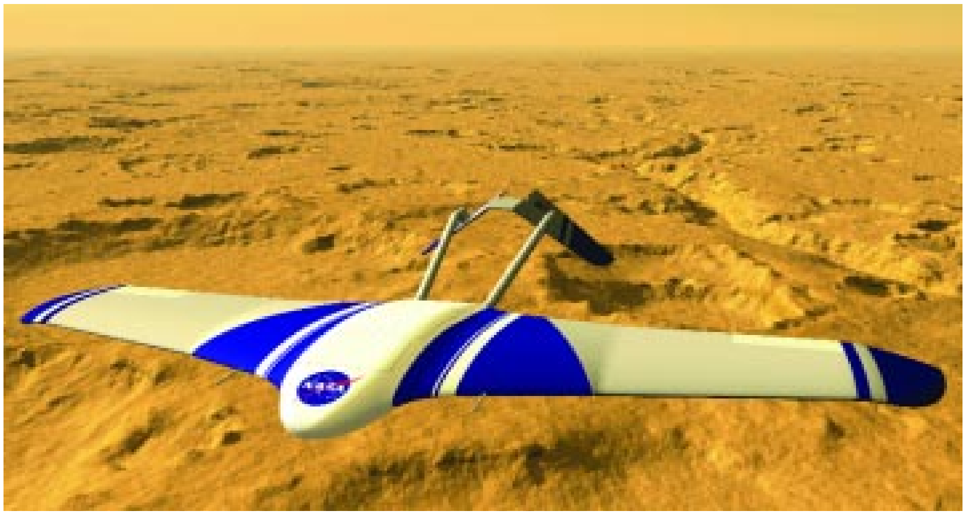


Figure 143: NASA develops winged flight vehicles, like this Mars flyer concept, that can operate in different and unique atmospheres.

NASA also is examining the application of aeronautical technologies to the atmospheres of other planets to design and create the mobile exploration vehicles of the future. NASA's major areas of technology research and development are: ultra-light, smart materials and structures to reduce aircraft weight; new energy sources like solar-powered fuel cells; intelligent power management systems; and autonomous control systems.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

Outcome 10.5.1: Develop technologies that will enable solar powered vehicles to serve as sub-orbital satellites for science missions.

As a result of the loss of the Helios prototype uncrewed aerial vehicle in June 2003, NASA reexamined the Agency's approach to developing technology for uncrewed aerial vehicles as sub-orbital platforms and cancelled APG 4AT18. The Helios prototype used energy derived from the Sun by day and from fuel cells at night. It was designed as the forerunner of high-altitude, uncrewed aerial vehicles that can fly ultra-long duration environmental science or telecommunications relay missions without using consumable fuels or emitting airborne pollutants. New plans call for NASA to test a regenerative fuel cell in an altitude chamber in FY 2009 to meet refined flight objectives for High Altitude Long Endurance.

Credit: NASA/T. Tschida

Figure 144: The Federal Aviation Administration has granted routine access to the National Airspace System (NAS) to high-altitude, long-endurance, remotely operated aircraft like the Altair Predator B, shown here taking to the air in its first check-out flight in June 2003. Access to the NAS was a critical step in utilizing the full capabilities of remotely operated aircraft.

Outcome 10.5.2: 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.

NASA made progress toward this Outcome by working with the Federal Aviation Administration on an agreement and recommendations for allowing High Altitude Long Endurance Remotely Operated Aircraft to operate in the National Airspace System. NASA achieved agreement on the portfolio of technologies and associated performance metrics that, if achieved, will allow routine operation of uncrewed aerial vehicles in the national airspace at Flight Level 400 or 40,000 feet (above where most planes fly). These technologies are being developed and will be demonstrated in actual flight tests. The results of these tests then will be provided to an external advisory committee, as required by law, prior to the Federal Aviation Administration issuing new policy or rules. Once vetted through the committee, the Federal Aviation Administration can issue new rules, policy, and directives required to enable routine, safe, and secure High Altitude Long Endurance Remotely Operated Aircraft access to the National Airspace System above Flight Level 400.

Performance Measures for Objective 10.5		2004 Rating	Past Years' Performance Measures and Ratings	2003	2002	2001
Outcome 10.5.1	Develop technologies that will enable solar powered vehicles to serve as sub-orbital satellites for science missions.	green		Outcomes originated in FY 2004		
APG 4AT18	Demonstrate the efficient performance of a flight-prototype regenerative energy storage system in an altitude chamber.	red		none	none	none
Outcome 10.5.2	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		Outcomes originated in FY 2004		
APG 4AT15	Deliver a validated set of requirements for UAV access at and above FL400, and a preliminary set of requirements for access at and above FL180.	green		none	none	none

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

Implementing Strategies to Conduct Well-Managed Programs

WHAT ARE IMPLEMENTING STRATEGIES AND WHY PURSUE THEM?

In addition to tracking and reporting performance on 10 Strategic Goals, NASA also monitors and reports on the Agency's performance in a number of management goals called Implementing Strategies. These strategies are not unique to NASA. They are organizational efficiency measures similar in purpose to the sound planning and management principles, practices, and strategies of all well-run organizations, and they are critical to NASA's achievement of the Agency's Strategic Goals, Objectives, Performance Outcomes, and APGs.

NASA's Implementing Strategy APGs are organized according to the Agency's 18 Budget Themes (e.g., Solar System Exploration, Mars Exploration Program, Astronomical Search for Origins) to emphasize individual program area accountability.

NASA'S PROGRESS AND ACHIEVEMENTS IN FY 2004

NASA's progress in the Agency's Implementing Strategy areas is documented in the following table. The NASA Performance Improvement Plan includes explanations for Implementing Strategy APGs that were rated Yellow, Red, or White. Performance trend information is unavailable for Implementing Strategy APGs since Implementing Strategies are new performance measures introduced in FY 2004.

Performance Measures for Implementing Strategies		2004 Rating	Comments
Solar System Exploration			
APG 4SSE1	Complete all development projects within 110% of the cost and schedule baseline.	yellow	The Solar System Exploration Theme successfully launched the MESSENGER mission to Mercury on August 3, 2004. MESSENGER was developed, completed, and launched within 110% of the schedule baseline, but exceeded the cost baseline established at the Mission Confirmation Review by 16.5%. This resulted in a Yellow rating on cost (4SSE1) and a Green rating on schedule (4SSE3).
APG 4SSE2	Each research project will allocate 75% of its funding competitively during FY 2004.	green	The Solar System Exploration Theme allocated 93% of its research funding competitively in FY 2004.
APG 4SSE3	SSE will complete all of its missions within 10% of their baseline schedules.	green	The Solar System Exploration Theme successfully launched the MESSENGER mission to Mercury on August 3, 2004. The MESSENGER mission was developed, completed, and launched within 110% of the schedule baseline, but exceeded the cost baseline established at the Mission Confirmation Review by 16.5%. This resulted in a Yellow rating on cost (4SSE1) and a Green rating on schedule (4SSE3).
Accomplish key development activities in support of Solar System Exploration			
APG 4SSE4	Successfully launch MESSENGER.	green	The Solar System Exploration Theme successfully launched the MESSENGER mission to Mercury on August 3, 2004.
APG 4SSE5	Deliver the Deep Impact spacecraft for Environmental Testing.	green	The Deep Impact spacecraft successfully completed environmental testing and is scheduled for launch in December 2004.
APG 4SSE6	Successfully complete the New Horizons/Pluto Critical Design Review (CDR).	green	The New Horizons/Pluto Critical Design Review was successfully completed in October 2003.
Accomplish key technology activities in support of Solar System Exploration			
APG 4SSE7	Define the Level One science goals for the Jupiter Icy Moons Orbiter (JIMO) Mission.	yellow	The JIMO Science Definition Team recommended goals, and NASA senior management plans to make final determination by mid-FY 2005.
APG 4SSE8	Release an NRA for high capability instruments useful on the JIMO Mission and follow-on Project Prometheus payloads.	green	The NASA Research Announcement for high-capability instruments for planetary exploration was released on July 23, 2003, ahead of schedule.
APG 4SSE9	Release an NRA for the next New Frontiers Mission.	green	The Announcement of Opportunity for the next New Frontiers mission was released on October 10, 2003.

Performance Measures for Implementing Strategies		2004 Rating	Comments
Mars Exploration Program			
APG 4MEP1	Complete all development projects within 110% of the cost and schedule baseline.	white	The Theme did not have any missions scheduled for development completion in FY 2004.
APG 4MEP2	Each research project will allocate 75% of its funding competitively during FY 2004.	green	The Mars Exploration Program Theme allocated 92% of its research funding competitively in FY 2004.
APG 4MEP3	MEP will complete all of its missions within 10% of their baseline schedules.	white	The Theme did not have any missions scheduled for development completion in FY 2004.
Accomplish key development activities in support of Mars Exploration			
APG 4MEP4	Successfully land at least one of the two Mars Exploration Rovers.	green	The twin Mars Exploration Rovers landed successfully on the surface of Mars; *Spirit* on January 3 in Gusev Crater and *Opportunity* on January 25 in the Meridiani Planum.
APG 4MEP5	Successfully complete the Level One Requirements for the Mars Exploration Rover Mission.	green	The Mars Exploration Rovers *Spirit* and *Opportunity* completed the mission's Level One requirements with astonishing success, and are currently in an extended operations phase, having lasted far beyond the anticipated operational timeframe.
APG 4MEP6	Successfully complete the 2005 Mars Reconnaissance Orbiter (MRO) Assembly, Test, and Launch Operations (ATLO) Readiness Review.	green	Successful completion of the 2005 Mars Reconnaissance Orbiter Assembly, Test, and Launch Operations Readiness Review occurred in March 2004.
Accomplish key technology activities in support of Mars Exploration			
APG 4MEP7	Complete Laser Communication Demonstration Concept Review.	green	NASA completed the Laser Communication Demonstration Concept Review in January 2004.
APG 4MEP8	Release Instrument Announcement of Opportunity (AO) for the 2009 Mars Science Laboratory (MSL).	green	NASA released the 2009 Mars Science Laboratory Instrument Announcement of Opportunity on April 14, 2004.
Astronomical Search for Origins			
APG 4ASO1	Complete all development projects within 110% of the cost and schedule baseline.	white	The Theme did not have any missions scheduled for development completion in FY 2004.
APG 4ASO2	Each research project will allocate 75% of its funding competitively during FY 2004.	green	The Astronomical Search for Origins Theme allocated 99% of its research funding competitively in FY 2004.
APG 4ASO3	ASO will complete all of its missions within 10% of their baseline schedules.	white	The Theme did not have any missions scheduled for development completion in FY 2004.
Accomplish key development activities in support of the Astronomical Search for Origins			
APG 4ASO4	Successfully complete Hubble Space Telescope (HST) Cosmic Origins Spectrograph (COS) development.	green	NASA successfully completed development of the Hubble Space Telescope Cosmic Origins Spectrograph.
APG 4ASO5	Successfully complete Stratospheric Observatory For Infrared Astronomy (SOFIA) Observatory Flight Test.	yellow	The Stratospheric Observatory For Infrared Astronomy Observatory flight test was not completed due to problems encountered with aerospace vendors and telescope installation. NASA overcame these problems, and the flight test is scheduled for FY 2005.
APG 4ASO6	Successfully complete Space Infrared Telescope Facility (SIRTF) In-Orbit Checkout (IOC) and Science Verification.	green	The Spitzer Space Telescope (formerly called the Space Infrared Telescope Facility), launched in August 2003, successfully completed its in-orbit checkout and science verification and is returning spectacular images from regions of space that are hidden from optical telescopes.
Accomplish key technology activities in support of the Astronomical Search for Origins			
APG 4ASO7	Establish and freeze James Webb Space Telescope (JWST) System-Level Requirements.	green	The James Webb Space Telescope System-Level Requirements were established and frozen with the completion of the mission System Requirements Review in December 2003.
APG 4ASO8	Validate Microarcsecond Metrology (MAM-1) Testbed progress toward interferometer sensor performance for Space Interferometry Mission (SIM).	green	NASA validated Microarcsecond Metrolog Testbed progress toward interferometer sensor performance for the Space Interferometry Mission with the completion of Technology Gate Seven in July 2004.
Structure and Evolution of the Universe			
APG 4SEU1	Complete all development projects within 110% of the cost and schedule baseline.	red	NASA successfully launched the Gravity Probe B mission in April 2004. However, development and launch of the mission far exceeded the cost (by 37%) and schedule baselines established at the Mission Confirmation Review due to unprecedented technical challenges.
APG 4SEU2	Each research project will allocate 75% of its funding competitively during FY 2004.	green	The Structure and Evolution of the Universe Theme allocated 97% of its research funding competitively in FY 2004.
APG 4SEU3	SEU will complete all of its missions within 10% of their baseline schedules.	red	NASA successfully launched the Gravity Probe B mission in April 2004. However, development and launch of the mission far exceeded the cost (by 37%) and schedule baselines established at the Mission Confirmation Review due to unprecedented technical challenges.
Accomplish key development activities to advance understanding of the Structure and Evolution of the Universe:			
APG 4SEU4	Successfully complete the Gamma-ray Large Area Space Telescope (GLAST) Mission Confirmation Design Review (CDR).	green	Successful completion of the Gamma-ray Large Area Space Telescope Mission Confirmation Design Review occurred in September 2004.
APG 4SEU5	Successfully launch Swift.	yellow	Completion and launch of the Swift spacecraft was also scheduled for FY 2004; however, due to technical problems and, more recently, hurricane-related delays, the launch is now scheduled for November 2004. Swift will exceed the schedule threshold and will exceed the cost baseline by approximately 40%.
APG 4SEU6	Successfully complete Pre-Ship Review of Astro-E2 instruments X-ray Spectrometer (XRS) and X-ray Telescope (XRT).	green	Successful completion of the Pre-Ship Reviews of the X-ray Spectrometer and X-ray Telescope was followed by shipment of these instruments to Japan for the Japanese Astro-E2 X-ray astronomy mission.
Accomplish key technology activities to advance understanding of the Structure and Evolution of the Universe:			
APG 4SEU7	Begin Formulation/Phase A for the Laser Interferometer Space Antenna (LISA) Mission.	green	NASA began Formulation/Phase A for the Laser Interferometer Space Antenna Mission with the completion of the Formulation Authorization Document.
APG 4SEU8	Complete Constellation-X (Con-X) design and fabricate the 8x8 Transition Edge Sensor Array for the X-ray Microcalorimeter Spectrometer.	green	NASA completed the design and fabrication of the Constellation-X Transition Edge Sensor Array for the X-ray Microcalorimeter Spectrometer.

Performance Measures for Implementing Strategies		2004 Rating	Comments
Sun-Earth Connection			
APG 4SEC1	Complete all development projects within 110% of the cost and schedule baseline.	white	The Theme did not have any missions scheduled for development completion in FY 2004.
APG 4SEC2	Each research project will allocate 75% of its funding competitively during FY 2004.	green	The Sun-Earth Connection Theme allocated 99% of its research funding competitively in FY 2004.
APG 4SEC3	SEC will complete all of its missions within 10% of their baseline schedules.	white	The Theme did not have any missions scheduled for development completion in FY 2004.
Accomplish key development activities to advance understanding of the Sun-Earth Connection:			
APG 4SEC4	Begin Solar Terrestrial Relations Observatory (STEREO) Integration & Testing (I&T).	yellow	Integration and testing of the Solar Terrestrial Relations Observatory spacecraft was delayed several months due to industry-wide thruster valve problems, and is now scheduled for early FY 2005.
APG 4SEC5	Begin Solar Dynamics Observatory (SDO) implementation.	green	The Solar Dynamics Observatory mission began implementation in FY 2004 with successful completion of the Mission Confirmation Review.
Accomplish key technology activities to advance understanding of the Sun-Earth Connection:			
APG 4SEC6	Release Announcement of Opportunity (AO) for Geospace Missions.	white	Release of the Announcement of Opportunity for Geospace Missions has been put on hold pending a re-prioritization of missions that will flow from NASA's new Science Mission Directorate strategic plan. It is anticipated that either a Geospace Missions Announcement of Opportunity or, if appropriate, a replacement would be released in FY 2005.
APG 4SEC7	Make AO selections for Magnetospheric Multiscale Mission.	green	NASA selected two Magnetospheric Multiscale Mission proposals for feasibility studies.
Earth System Science			
APG 4ESS1	Complete all development projects within 110% of the cost and schedule baseline.	green	The Earth System Science Theme examined development cost changes for the one project launched in FY 2004, Aura, and the increase in development cost from the initial baseline estimate to the FY 2006 draft budget submit was 10%. The Aura project was within cost and schedule and, therefore, within the measure parameters.
APG 4ESS2	Research: Each research project will allocate 80% of its funding competitively during FY 2004.	green	The Earth System Science Theme allocated 82% of its funding competitively in FY 2004.
APG 4ESS3	Development: Each project will complete its mission within 10% of its baseline schedules.	red	With respect to development, see the Detailed Performance Improvement Plan.
APG 4ESS4	Technology: Successfully develop and infuse technologies that will enable future science measurements by 1) advancing 25% of funded technology developments one Technology Readiness Level, and 2) maturing 2-3 technologies to the point where they can be demonstrated in space or in an operational environment.	green	Development projects were advanced by at least one technology readiness level and three technologies were matured to the point where they can be demonstrated in space or in an operational environment.
APG 4ESS5	Operations: At least 90% of all on-orbit instruments will be operational during their design lifetimes.	green	This Theme has 15 missions currently in operation: eight of them are in Primary Mission phase. The remaining seven are in Extended Mission phase. There are a total of 43 instruments in orbit, with 39 operating. Of those, 20 are in Primary Mission phase and are in operation. One hundred percent of on orbit instruments in Primary Mission phase are operational. The percentage of all on orbit instruments operating (including Extended Mission phase) is 90.7%.
APG 4ESS6	Data information systems and services: Disseminate data that are easy to access to science focus area customers.	green	NASA made an unprecedented volume of data available to researchers in the Earth science research focus areas. Reprocessed data from the Terra and Aqua missions, with improved calibration and science quality, were available online through the Earth Observing System Data and Information System (EOSDIS). The National Quality Research Center at the University of Michigan conducted a customer satisfaction study for NASA, and the results confirmed NASA's success in disseminating data to its customers. The American Customer Satisfaction Index score for EOSDIS was 75, exceeding both the national average for all industries and the national average for Federal agencies. The study results, based on a survey of over 1,000 EOSDIS users, indicated that the users (primarily science researchers) were very satisfied with the products and services provided by EOSDIS and the Distributed Active Archive Centers
Earth Science Applications			
APG 4ESA7	Deliver at least 90% of operating hours for all operations and research facilities.	green	This Theme uses E-Government tools and information system/engineering facilities to execute program activities efficiently. In FY 2004, unplanned downtime for all tools and facilities was less than 1%.
APG 4ESA8	At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.	green	In addition, this Theme's management uses competitive techniques (open solicitations, competitive contracting, and peer review) to achieve high performance and best value for the program to the greatest extent practical. Of the $100.5 million Theme budget, $75.4 million was available for research projects after institutional costs were subtracted. Of that, over $61 million (81%) of funded projects were implemented using competitive techniques.
Biological Sciences Research			
APG 4BSR18	Complete all development projects within 110% of the cost and schedule baseline.	green	Biological Sciences Research completed the development of the second Human Research Facility and was ready for launch in March 2003. Due to the stand-down of flights after the Columbia accident, this hardware was put on hold until return to flight. Within the downtime, regular maintenance, upgrades, and reviews incurred additional costs above the baseline. Therefore, the second Human Research Facility project was evaluated above the cost and schedule baseline for 2004.
APG 4BSR19	At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.	green	In FY 2004, 100% of the Bioastronautics Research projects, both intramural and extramural, were peer-reviewed and competitively awarded.

Performance Measures for Implementing Strategies		2004 Rating	Comments
Physical Sciences Research			
APG 4PSR10	Complete all development projects within 110% of the cost and schedule baseline.	green	Issues with the Shuttle and International Space Station programs affected costs associated with Physical Sciences Research flight projects. NASA cut program content to produce better strategic alignment between Agency goals and program objectives. However, the remaining content has shown good cost control within the limits of controllable factors.
APG 4PSR11	At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.	green	Information on research project awards was not reported.
Research Partnerships and Flight Support			
APG 4RPFS11	Deliver at least 90% of operating hours for all operations and research facilities.	green	NASA's Payload Operations and Integration Center continuously ran the research operations for the International Space Station.
Aeronautics Technology			
APG 4AT1	Complete all development projects within 110% of the cost and schedule baseline.	white	The Aeronautics Theme had no development projects in the FY 2004 Performance Plan.
APG 4AT2	The Theme will allocate 75% of its procurement funding competitively during FY 2004.	green	The Theme obligated in excess of 90% of its procurement funding on competitively awarded contractual vehicles.
APG 4AT3	The Theme will complete 90% of the major milestones planned for FY 2004.	green	The Theme completed 92% of its planned major milestones in FY 2004.
Education			
APG 4ED24	At least 80%, by budget, of research projects will be peer-reviewed and competitively awarded.	green	The majority of NASA's education program opportunities were competitively awarded.
Transportation Systems			
APG 4TS5	The Theme will distribute at least 80% of its allocated procurement funding to competitively awarded contracts.	green	NASA's Constellation Systems team distributed 95% of its allocated procurement funding to competitively awarded contracts.
Human and Robotic Technologies			
APG 4HRT13	Distribute at least 80% of allocated procurement funding to competitively awarded contracts, including continuing and new contract activities.	green	NASA's Exploration Systems Research and Technology team (formerly Human and Robotics Technologies) developed and implemented a competitive funding process for all new research and technology investments. The team also completed an intramural call for proposals with external proposal review that resulted in 50 awards to NASA Centers, with external and cross-Center participation. The team also completed the initial phase of an external call for proposals; 498 Notices of Intent from industry, academia, and other government organizations were approved from over 3,700 Notices received. NASA expects to make awards in November 2004.
International Space Station			
APG 4ISS7	Complete all development projects within 110% of the cost and schedule baseline.	green	The International Space Station program continues to manage within the baseline established by the FY 2004 President's budget. The development phase (element development prior to Shuttle integration) has been within 110% of cost and schedule. Station assembly has been halted while the Space Shuttle fleet is grounded. However, development activity has continued in order to minimize schedule impacts. The FY 2004 Appropriation reduced the Station program by $200 million, but the program maintained the same content. The FY 2005 President's Budget Request maintained the baseline, while adding crew/cargo services content and funding to the program baseline. The Station program plans to re-baseline in FY 2006 after the Shuttle returns to flight.
APG 4ISS8	The ISS Program will complete all of its missions within 10% of its baseline schedules.	green	In keeping with NASA's response to the Columbia Accident Investigation Board, the Agency will be driven by safety rather than schedule. Therefore, NASA will continue to be milestone-driven rather than schedule-driven.
Space Shuttle Program			
APG 4SSP5	Complete all development projects within 110% of the cost and schedule baseline.	green	The Space Shuttle program is pursuing the Advanced Health Management System and Cockpit Avionics Upgrade development projects. Both projects remained within 110% of the cost and schedule baseline.
APG 4SSP6	Space Shuttle Program will execute its program within 10% of its baseline schedules.	green	In keeping with NASA's response to the Columbia Accident Investigation Board, the Agency will be driven by safety rather than schedule. Therefore, as NASA works towards safe return to flight, the Space Shuttle program will continue to be milestone-driven rather than schedule-driven.
Space and Flight Support			
APG 4SFS14	Complete all development projects within 110% of the cost and schedule baseline.	green	Space Flight Support programs are operational in nature and have operated within 110% of their cost and schedule baselines.
APG 4SFS15	Space and Flight Support will execute its programs within 10% of its baseline schedules.	green	In keeping with NASA's response to the Columbia Accident Investigation Board, the Agency will be driven by safety rather than schedule. Therefore, as NASA works towards safe return to flight, this program will continue to be milestone-driven rather than schedule-driven.

Performance Measures for Implementing Strategies		2004 Rating	Comments
Space and Flight Support			
APG 4SFS14	Complete all development projects within 110% of the cost and schedule baseline.	green	Space Flight Support programs are operational in nature and have operated within 110% of their cost and schedule baselines.
APG 4SFS15	Space and Flight Support will execute its programs within 10% of its baseline schedules.	green	In keeping with NASA's response to the Columbia Accident Investigation Board, the Agency will be driven by safety rather than schedule. Therefore, as NASA works towards safe return to flight, this program will continue to be milestone-driven rather than schedule-driven.

Note: See NASA's Performance Improvement Plan at the end of Part 2 for details on FY 2004 APGs and Outcomes rated Red, Yellow, or White.

NASA's Performance Improvement Plan

The following table reports on the performance measures (Outcomes and APGs) that NASA was unable to achieve fully in FY 2004. The table is organized by Strategic Goal. For each Performance Outcome and/or APG that NASA did not achieve fully, the table includes an explanation of the specific performance problem, the reason(s) for less than fully successful performance, and NASA's plan and schedule to achieve or discontinue the Outcome or APG.

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
2	APG 4AT19	Complete detailed design of a low-emission combustor leading to a 2005 test of a full-annular combustor demonstrating a 70% reduction of nitrogen oxides.	Yellow	The design of the low emission combustor is not yet complete.	The schedule slip was a result of the FY 2004 Continuing Resolution and the delay in receiving spending authority (not received until February 2004) to put funds on the contracts for this effort.	Expected completion date is December 30, 2004. This is an interim step toward achieving the FY 2007 goal. There is currently sufficient schedule reserve to accommodate this slip without impacting the final deliverable.	Not applicable
2	APG 4AT9	Experimentally demonstrate a 2-stage highly loaded compressor for increasing pressure rise per stage.	Yellow	The test of the two-stage highly loaded compressor has not yet been accomplished. All the hardware has been fabricated. Assembly and instrumentation currently in progress.	This APG will slip into FY 2005. Most of the compressor components for the facility have been manufactured and have been heavily instrumented since this will be a research facility. Upon installation, a problem occurred with the match balancing of the shafts. Repeatability of the balancing has not been achieved, and further installation of components cannot take place until the shaft is balanced.	Expected completion date is November 30, 2004.	Not applicable
3	APG 4AT14	Conduct and obtain flight test data of autonomous aerial refueling technologies in support of DoD UCAV Program.	White	The project was cancelled before the goal could be achieved.	Funds were redistributed from this project to other higher priority projects.	No current plans to continue this goal.	Not applicable
3	Outcome 3.2.3,	By 2008, develop and test at least two design tools for advanced materials and in-space fabrication, and validate on ISS.	Yellow	PSR is not on track to develop and test at least two design tools for advanced materials and in-space fabrication, and validate on ISS.	Because of the Columbia accident, there have been no Shuttle flights to the ISS. Once the Shuttle resumes flight, there will be limited access to it and the ISS. Since in-space fabrication supports the new Vision for Space Exploration, this goal is still viable. However, validation on the ISS may not be possible.	Once the Shuttle resumes flight, there will be very limited access to it and the ISS.	Not applicable
	APG RPFS4	Continue synthesis of zeolite crystals on ISS.					

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
3	Outcome 3.2.5	By 2008, increase by 30% (from the 2003 level) the utilization of NASA/OBPR-derived technologies by other agencies, private sector, and academia to advance basic and applied research goals of practical impact.	White	This Outcome and its related APG have been superseded by Agency direction. Research content related to this Outcome has been deleted in order to support content better focused on tasks with greater exploration relevance.	Not applicable	Not applicable	Not applicable
	APG 4PSR1	Maintain an active research program in collaboration with other agencies in laser light scattering, bioreactor, and containerless technologies.					
3	Outcome 3.3.1	By 2008, analyze the impact of the results of the first phase of ISS and ground-based research in biotechnology, fundamental science, and engineering to demonstrate the introduction of at least two new design tools and/or process improvements to existing technologies and industrial practices.	White	This Outcome and its related APG have been superseded by Agency direction. Research content related to this Outcome has been deleted in order to support content better focused on tasks with greater exploration relevance.	Not applicable	Not applicable	Not applicable
	APG 4PSR2	Demonstrate the productivity of the research program in combustion, fluids physics, biotechnology, and materials science and accomplish the milestones of ISS research projects.					
4	Outcome 4.2.1	By 2008, complete the first generation of ISS research in colloidal physics and soft condensed matter and demonstrate the ability to control the colloidal engineering of at least two different model structures.	White	This Outcome and its related APG have been superseded by Agency direction. Research content related to this Outcome has been deleted in order to support content better focused on tasks with greater exploration relevance.	Not applicable	Not applicable	Not applicable
	APG 4PSR4	Demonstrate the productivity of the colloidal physics and soft-condensed matter program and accomplish the planned ISS research projects milestones.					
4	Outcome 4.2.2	By 2008, complete the design and fabrication of the first ISS fundamental microgravity physics facility to allow the performance of two capstone investigations in dynamical critical phenomena.	White	This Outcome and its related APG have been superseded by Agency direction. Research content related to this Outcome has been deleted in order to support content better focused on tasks with greater exploration relevance.	Not applicable	Not applicable	Not applicable
	APG 4PSR5	Demonstrate the accomplishments of the ISS fundamental physics facility development milestones and maintain a productive ground and space-based research program in condensed matter physics.					

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
4	Outcome 4.2.3	By 2008, complete the design for the ISS laser-cooling laboratory and demonstrate the feasibility to deploy the most accurate atomic clock in space.	White	This Outcome and its related APG have been superseded by Agency direction. Research content related to this Outcome has been deleted in order to support content better focused on tasks with greater exploration relevance.	Not applicable	Not applicable	Not applicable
	APG 4PSR6	Demonstrate the accomplishments of the ISS laser cooling and atomic physics facility milestones and maintain an innovative and productive ground and space-based research program in atomic and gravitational physics.					
4	Outcome 4.2.4	By 2008, complete the first phase of the ISS biotechnology facility and demonstrate cellular biotechnology research throughput increase by a factor of two.	White	This Outcome and its related APG have been superseded by Agency direction. Research content related to this Outcome has been deleted in order to support content better focused on tasks with greater exploration relevance.	Not applicable	Not applicable	Not applicable
	APG 4PSR7	Demonstrate the accomplishments of the ISS biotechnology research facility development milestones and maintain a productive and innovative ground and space-based research program in cellular biotechnology and tissue engineering.					
5	Outcome 5.1.1	Understand the initial stages of planet and satellite formation.	Yellow	Although NASA made progress in understanding the initial stages of planet and satellite formation, because the parachute on Genesis's sample return capsule did not deploy, the mission received a Yellow rating by the expert external reviewer. (See progress text under Objective 5.1 for details of non-Genesis achievements in this science area.)	Although NASA made progress in understanding the initial stages of planet and satellite formation, because the parachute on Genesis's sample return capsule did not deploy, the mission received a Yellow rating by the expert external reviewer.	Although Genesis scientists expect to achieve most of the science objectives through samples recovered from the capsule, the results will be evaluated during FY 2005 when detailed laboratory analysis is performed. NASA's Science Mission Directorate will request that the expert external review, which will be conducted to evaluate FY 2005 scientific progress, include a reassessment of this FY 2004 rating.	Not applicable
5	APG 4SSE12	Successfully demonstrate progress in understanding the initial stages of planet and satellite formation. Progress towards achieving outcomes will be validated by external review.	Yellow	Although NASA made progress in understanding the initial stages of planet and satellite formation, because the parachute on Genesis's sample return capsule did not deploy, the mission received a Yellow rating by the expert external reviewer. (See progress text under Objective 5.1 for details of non-Genesis achievements in this science area.)	Although NASA made progress in understanding the initial stages of planet and satellite formation, because the parachute on Genesis's sample return capsule did not deploy, the mission received a Yellow rating by the expert external reviewer.	Although Genesis scientists expect to achieve most of the science objectives through samples recovered from the capsule, the results will be evaluated during FY 2005, as detailed laboratory analysis is performed. NASA's Science Mission Directorate will request that the expert external review, which will be conducted to evaluate FY 2005 scientific progress, include a reassessment of this FY 2004 rating.	Not applicable

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
6	APG 4ED9	Develop an inventory identifying the number of first-time proposers and the universe of faculty in higher education institutions involved with NASA research and development opportunities.	Red	The number of first-time proposers in the universe of faculty in higher education has not been catalogued.	NASA has not met this performance goal since it was just initiated in FY 2004, and NASA is tracking that information from all grant proposers.	The question of whether or not a faculty member is proposing for the first time to NASA is now being tracked in FY 2005, and NASA will establish an inventory and baseline.	Not applicable
8	APG 4SSP1	Implement necessary modifications to the Space Shuttle system for return to flight in FY 2004.	Yellow	The Shuttle fleet remained grounded in FY 2004 to allow time to implement all of the return to flight recommendations from the Columbia Accident Investigation Board. NASA continues to perform those activities that will lead to a safe return to flight in FY 2005.	The Final Report of the Columbia Accident Investigation Board identified a number of systemic cultural, organizational, and managerial issues within the Shuttle program and NASA as a whole that contributed to the loss of *Columbia* on February 1, 2003. The Board identified 15 return to flight and 14 long-term recommendations designed to address these issues. The complexity of the technical challenges associated with completing these recommendations has delayed the current return to flight launch window to no earlier than May 2005.	NASA continues to perform those activities that will lead to a safe return to flight in FY 2005. In FY 2004, the Space Shuttle program successfully conditionally closed five of the 15 return to flight recommendations with the Return to Flight Task Group and continued to make progress toward closing the remaining recommendations in early FY 2005.	Not applicable
8	APG 4SSP2	Achieve zero Type-A (damage to property at least $1M or death) or Type-B (damage to property at least $250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY 2004.	Yellow	Although there were no Type A mishaps in FY 2004, NASA failed to achieve this APG due to the occurrence of one Type B mishap.	A Space Shuttle Main Engine #2052 low-pressure fuel duct was damaged while the engine was being moved at the Stennis Space Center. This resulted in $600,000 worth of damage, but no injuries.	The Shuttle program has adopted corrective actions to prevent this type of mishap in the future. Procedures requiring transportation of Space Shuttle Main Engines to and from the test stands and engine shop have been updated to incorporate a Move Director and crew briefing templates to assure all required information is transmitted to the move crews. Approval from the NASA Stennis Space Center Site Director is now required for Space Shuttle Main Engine transports.	Not applicable
8	APG 4SSP3	Achieve 100% on-orbit mission success for all Shuttle missions launched in FY 2004. For this metric, mission success criteria are those provided to the prime contractor (SFOC) for purposes of determining successful accomplishment of the performance incentive fees in the contract.	White	The Space Shuttle fleet remained grounded in FY 2004 to allow time to implement all of the return to flight recommendations from the Columbia Accident Investigation Board.	NASA will not launch the Shuttle until all 15 return to flight recommendations have been adequately addressed, as determined by the Return to Flight Task Group, co-chaired by former astronauts Thomas Stafford and Richard Covey. The complexity of the technical challenges associated with completing these recommendations has delayed the current return to flight launch window to no earlier than May–July 2005.	NASA continues to perform those activities that will lead to a safe return to flight in FY 2005. In FY 2004, the Shuttle program successfully conditionally closed five of the 15 return to flight recommendations with the Return to Flight Task Group and continued to make progress towards closing the remaining recommendations in early FY 2005.	Not applicable

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
8	APG 4ISS2	Achieve zero Type-A (damage to property at least $1M or death) or Type-B (damage to property at least $250K or permanent disability or hospitalization of 3 or more persons) mishaps in FY 2004.	Yellow	There was one Type-B mishap during FY 2004.	In October 2003, a spare Cupola window was crushed at the Dow Corning plant. Damage was estimated at $300,000. There were no injuries. The investigation board concluded its activities in May 2004, after completing of its report on the mishap.	The Cupola mishap investigation report will be reviewed for applicable lessons learned. Safety remains a top priority for the ISS Program, contractors, and their facilities.	Not applicable
10	APG 4HRT8	Establish 3 partnerships with U.S. industry and the investment community using the Enterprise Engine concept.	Yellow	The original performance goal was to establish three partnerships with U.S. industry and the investment community using the Enterprise Engine concept.	The goal has not been met for three reasons. First, this was a new project in FY 2004. NASA was under a continuing resolution, and this project was not funded at the start of the fiscal year. Funding was finally available in the second quarter of FY 2004. Second, although significant interest has been raised by the venture capital and corporate investment communities to start to generate deal flow, of these initial opportunities, none has cleared NASA's investment criteria (i.e., those opportunities serving NASA mission needs and providing multi-use technologies). Third, in deciding to capitalize on the advantages of following the Central Intelligence Agency's In-Q-Tel venture capital opera-ting model, resources have been focused on establishing a non-profit corporation to act as NASA's agent for investment transactions. This is an imperative for the future of this initiative.	The team is working to generate further deal flow, and is currently in the progress of hiring a law firm to assist in the establishment of a non-profit organization to act as NASA's agent for investment transactions. The current forecast is that this organization, complete with the recruitment of a board of trustees, will be completed by the start of calendar year 2005. The first partnership/transaction is forecast to be completed by the end of the second quarter of FY 2005.	No change recommended, this goal will be met or exceeded in FY 2005
10	APG 4AT18	Demonstrate the efficient performance of a flight-prototype regenerative energy storage system in an altitude chamber.	Red	As a result of the loss of the Helios aircraft, the program was reformulated and the altitude chamber test of the flight-prototype regenerative energy storage system was replanned for FY 2009.	The system was designed to be used on the Helios uncrewed aerial vehicle. After the loss of this aircraft, the program was replanned in conjunction with NASA's Earth Science community users. As a result, NASA decided to proceed with development of a more capable uncrewed aerial vehicle rather than build another Helios system. The regenerative energy storage system will be redesigned to support this new vehicle and will undergo altitude chamber testing in FY 2009.	Replanned for improved system to be tested in FY 2009	Not applicable

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
Imple-menting Strategies	APG 4SSE1	Complete all development projects within 110% of the cost and schedule baseline.	Yellow	NASA did not successfully complete MESSENGER mission development within 110% of the cost baseline established at the Mission Confirmation Review.	NASA successfully launched the MESSENGER mission on August 3, 2004. Development and launch of the MESSENGER mission was completed within 110% of the schedule baseline, but exceeded the cost baseline established at the Mission Confirmation Review by 16.5%; this resulted in a Yellow rating on cost (APG 4SSE1) and a Green rating on schedule (APG 4SSE3).	This type of metric cannot be met at a later date. NASA assigns Yellow to those cost and schedule APGs that are missed by a relatively small margin, and Red to those missed by a large margin.	Not applicable
Imple-menting Strategies	APG 4SSE7	Define the Level One science goals for the Jupiter Icy Moons Orbiter (JIMO) Mission	Yellow	Definition of the Level One science goals for the Jupiter Icy Moons Orbiter mission has not been finalized.	The Jupiter Icy Moons Orbiter Science Definition Team recommended goals; however, a change in the planned Jupiter Icy Moons Orbiter launch date and corresponding release of the Announcement of Opportunity delayed the need for final definition.	The Jupiter Icy Moons Orbiter Science Definition Team recommended goals, which are being reviewed by NASA's Science Mission Directorate senior management; final determination is antici-pated in mid-FY 2005.	Not applicable
Imple-menting Strategies	APG 4MEP1	Complete all development projects within 110% of the cost and schedule baseline.	White	Annual Performance Goal not applicable; no Mars Exploration Program missions scheduled for completion or launch in FY 2004.	Not applicable	Not applicable	Not applicable
Imple-menting Strategies	APG 4MEP3	MEP will complete all of its missions within 10% of their baseline schedules.	White	Annual Performance Goal not applicable; no Mars Exploration Program missions sche-duled for completion or launch in FY 2004.	Not applicable	Not applicable	Not applicable
Uniform Measures	APG 4ASO1	Complete all development projects within 110% of the cost and schedule baseline.	White	Annual Performance Goal not applicable; no Mars Exploration Program missions scheduled for completion or launch in FY 2004.	Not applicable	Not applicable	Not applicable
Imple-menting Strategies	APG 4ASO3	ASO will complete all of its missions within 10% of their baseline schedules.	White	Annual Performance Goal not applicable; no Mars Exploration Program missions scheduled for completion or launch in FY 2004.	Not applicable	Not applicable	Not applicable
Imple-menting Strategies	APG 4ASO5	Successfully complete Stratospheric Observa-tory for Infrared Astronomy (SOFIA) Observatory Flight Test	Yellow	The Stratospheric Observatory for Infrared Astronomy did not complete its flight test.	Several aerospace vendor problems were encoun-tered, including vendor bankruptcy and parts not manufactured to speci-fications, requiring re-manufacturing. Also, it proved much more chal-lenging than anticipated to install the German telescope into the 747 airplane to conduct key integration tests following the installation and to conduct the major ground test of the airplane modification (i.e., fuselage proof pressure test).	NASA overcame these problems, but the flight test is delayed until FY 2005.	Not applicable

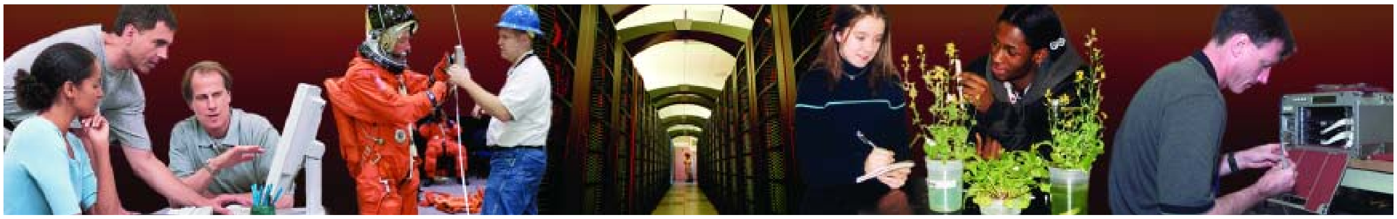
Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
Implementing Strategies	APG 4SEU1	Complete all development projects within 110% of the cost and schedule baseline.	Red	NASA did not successfully complete Gravity Probe B and Swift mission development within 110% of the cost baseline established at the Mission Confirmation Reviews.	NASA successfully launched the Gravity Probe B mission in April 2004. However, development and launch of the mission far exceeded the cost (by 37%) and schedule baselines established at the Mission Confirmation Review due to unprecedented technical challenges. Completion and launch of the Swift spacecraft was also scheduled for FY 2004; however, due to technical problems and, more recently, hurricane-related delays, the launch is now scheduled for November 2004. Swift also will exceed the schedule threshold, and will exceed the cost baseline by approximately 40%.	This metric cannot be met at a later date. NASA assigns Yellow to those cost and schedule APGs that are missed by a relatively small margin, and Red to those missed by a large margin. When the Gravity Probe B program was cancelled three times due to poor performance (and Congressional appropriators restored its funding each time), NASA reviewed the program to restrain cost and schedule growth. NASA held project managers to strict standards for mission progress, with cancellation as the alternative if standards were not met. In early 2003, an independent review team evaluated mission development progress to date. The team put forth requirements for continuation. The project implemented them and Gravity Probe B launched in April 2004.	Not applicable
Implementing Strategies	APG 4SEU3	SEU will complete all of its missions within 10% of their baseline schedules.	Red	NASA did not successfully complete Gravity Probe B and Swift mission development within 110% of the schedule baseline established at the Mission Confirmation Reviews.	NASA successfully launched the Gravity Probe B mission in April 2004. However, development and launch of the mission far exceeded the schedule baseline established at the Mission Confirmation Review due to unprecedented technical challenges. Completion and launch of the Swift spacecraft was also scheduled for FY 2004; however, due to technical problems and, more recently, hurricane-related delays, the launch is now scheduled for November 2004. Swift also will exceed the schedule threshold.	This metric cannot be met at a later date. NASA assigns Yellow to those cost and schedule APGs that are missed by a relatively small margin, and Red to those missed by a large margin. When the Gravity Probe B program was cancelled three times due to poor performance (and Congressional appropriators restored its funding each time), NASA reviewed the program to restrain cost and schedule growth. NASA held project managers to strict standards for mission progress, with cancellation as the alternative if standards were not met. In early 2003, an independent review team evaluated mission development progress to date. The team put forth requirements for continuation. The project implemented them and Gravity Probe B launched in April 2004.	Not applicable

Goal	Performance Measure	Description	Rating	Explanation/description of where a performance goal was not met	Why the goal was not met	Plans and schedules for achieving the goal	If the goal is impractical or infeasible, why that is the case and what action is recommended
Imple-menting Strategies	APG 4SEU5	Successfully launch Swift.	Yellow	Swift was not success-fully launched.	The Swift launch date slipped from December 2003 to September 2004 due to technical difficulties with instrument develop-ment and the replacement of a damaged instrument power electronics board. The slip from September 2004 to November 2004 is due to launch pad sche-duling and hurricane-related delays.	The launch is scheduled for November 2004.	Not applicable
Imple-menting Strategies	APG 4SEC1	Complete all development projects within 110% of the cost and schedule baseline.	White	This APG was not applicable; no Sun–Earth Connection missions were sche-duled for completion and launch in FY 2004.	Not applicable	Not applicable	Not applicable
Imple-menting Strategies	APG 4SEC3	SEC will complete all of its missions within 10% of their baseline schedules.	White	This APG was not applicable; no Sun–Earth Connection missions were sche-duled for completion/launch in FY 2004.	Not applicable	Not applicable	Not applicable
Imple-menting Strategies	APG 4SEC4	Begin Solar Terrestrial Relations Observatory (STEREO) Integration and Testing (I&T)	Yellow	The STEREO mission did not begin inte-gration and testing.	Integration and testing slipped three months due to industry-wide thruster valve problems.	Integration and testing is currently scheduled to start at the end of January 2005. This delay has resulted in a three-month slip to the launch date (now February 2006), with a corresponding delay in the start of mission science. STEREO will measure the causes and mechanisms of Coronal Mass Ejection initiation and character-ization of their propagation through the heliosphere.	Not applicable
Imple-menting Strategies	APG 4SEC6	Release Announcement of Opportunity (AO) for Geospace Missions	Yellow	Announcement of Opportunity for Geospace Missions was not released.	The Announcement of Opportunity is on hold while the cost of the program is reassessed in recognition of new budget priorities.	Upon receiving an approved program budget and a new set of Explo-ration-prioritized goals, a timeline for the release of the Geospace Announce-ment of Opportunity will be determined.	Not applicable
Imple-menting Strategies	APG 4ESS3	Development: Each project will complete its mission within 10% of its baseline schedules.	Red	The Earth Science program examined schedule changes for three projects in mid-FY 2004, and the average increase in develop-ment schedule from the initial baseline estimate to the FY 2006 budget submit was 13%.	Calipso and Cloudsat were the two projects over the 10% performance metric. Several technical issues led to poor schedule performance, thus increasing mission cost.	This poor performance initiated a subsequent re-baseline activity. At this time, there are no changes anticipated. Projects are now under new baseline controls.	The goal is prac-tical and feasible. Action was taken to resolve the problem (e.g., the activity was re-baselined, and NASA expects that the new baseline controls will enable this goal to be achieved in FY 2005).
Imple-menting Strategies	APG 4AT1	Complete all development projects within 110% of the cost and schedule baseline.	White	Annual Performance Goal was not applicable since there were no development projects within the Aeronautics Theme.	Not applicable	Not applicable	Not applicable

Part 3

Financials

Letter from the Chief Financial Officer



This section of the National Aeronautics and Space Administration's (NASA) *Fiscal Year 2004 Performance and Accountability Report* contains the annual financial statements and associated audit reports. NASA received a disclaimer of audit opinion for the FY 2004 financial statements.

While NASA achieved measurable improvements in its financial management practices during FY 2004, much work remains to achieve an unqualified audit opinion. We anticipated the ongoing challenges of implementing an organization-wide integrated financial management system and adopting full cost business practices at the Agency, and we carefully mapped an ambitious but doable plan to remedy residual system conversion data problems, achieve full and compliant accountability of property, plant, and equipment, and prepare for future integrated system functionality.

Transformation of NASA Headquarters, including the Office of the Chief Financial Officer, solidified much-needed organizational stability and improved accountability. Chief financial officers at NASA's Centers now report directly to me. In addition, we have integrated the Office of Procurement and the Office of Small and Disadvantaged Business Utilization into the Office of the Chief Financial Officer to ensure that financial policies, processes, and practices are consistent and connected through NASA's entire life cycle of financial transactions and events. We are clearly positioning ourselves to become the "best in government" for financial management.

My staff and I look forward to working with the entire NASA community and our auditors during the coming year to improve significantly our future financial management within the Agency.

Gwendolyn Sykes
Chief Financial Officer and Chief Procurement Officer

FINANCIAL OVERVIEW

SUMMARY OF FINANCIAL RESULTS, POSITION, AND CONDITION

NASA's financial statements were prepared to report the financial position and results of operations of the Agency. The principal financial statements include 1) the Consolidated Balance Sheet, 2) Consolidated Statement of Net Cost, 3) Consolidated Statement of Changes in Net Position, 4) Combined Statement of Budgetary Resources, and 5) Consolidated Statement of Financing. Additional financial information is also presented in the notes and required supplementary schedules.

The *Chief Financial Officers Act of 1990* requires that agencies prepare financial statements to be audited in accordance with Government Auditing Standards. The financial statements were prepared from the NASA Integrated Financial Management system (SAP) and other Treasury reports, in accordance with Generally Accepted Accounting Principles and accounting policies and practices summarized in this note. The statements should be read with the realization that NASA is a component of the U.S. Government, a sovereign entity. The following paragraphs briefly describe the nature of each required financial statement and its relevance. Significant account balances and financial trends are discussed to help clarify their impact upon operations.

CONSOLIDATED BALANCE SHEET

The Consolidated Balance Sheet on page 191 is presented in a comparative format providing financial information for fiscal years 2004 and 2003. It presents assets owned by NASA, amounts owed (liabilities), and amounts that constitute NASA's equity (net position). Net position is presented on both the Consolidated Balance Sheet and the Consolidated Statement of Changes in Net Position.

CONSOLIDATED STATEMENT OF NET COST

The Consolidated Statement of Net Cost on page 192 presents the "income statement" (the annual cost of programs) and distributes fiscal year expenses by appropriation symbol. The Net Cost of Operations is reported on the Consolidated Statement of Net Cost, the Consolidated Statement of Changes in Net Position, and also on the Combined Statement of Financing.

CONSOLIDATED STATEMENT OF CHANGES IN NET POSITION

The Consolidated Statement of Changes in Net Position displayed on page 194 identifies appropriated funds used as a financing source for goods, services, or capital acquisitions. This Statement presents the accounting events that caused changes in the net position section of the Consolidated Balance Sheet from the beginning to the end of the reporting period. Cumulative Results of Operations represents the public's investment in NASA, akin to stockholder's equity in private industry.

COMBINED STATEMENT OF BUDGETARY RESOURCES

The Combined Statement of Budgetary Resources on page 195 highlights budget authority for the Agency and provides information on budgetary resources available to NASA for the year and the status of those resources at the end of the year.

Funding was received and allocated through the following appropriations:

- **Space Flight Capabilities**—This appropriation provided for the International Space Station and Space Shuttle programs, including the development of research facilities for the International Space Station; continuing safe, reliable access to space through augmented investments to improve Space Shuttle safety; support of payload and expendable launch vehicle operations; and other investments including innovative technology development, commercialization, research technology development for future exploration, and initial studies for a future crew exploration vehicle.
- **Science, Aeronautics, and Exploration**—This appropriation provided for NASA's research and development activities, including all science activities, global change research, aeronautics, technology investments, education programs, space operations, and direct program support.
- **Inspector General**—This appropriation provided for the workforce and support required to perform audits, evaluations, and investigations of programs and operations.

CONSOLIDATED STATEMENT OF FINANCING

The Consolidated Statement of Financing on page 196 provides the reconciliation between the obligations incurred to finance operations and the net costs of operating programs.

National Aeronautics and Space Administration
Consolidated Balance Sheet
As of September 30, 2004 and September 30, 2003
(In Thousands of Dollars)

		2004		2003
Assets				
Intragovernmental Assets				
Fund Balance with Treasury (Note 2)	$	7,629,298	$	7,492,506
Investments (Note 3)		17,077		17,138
Accounts Receivable, Net (Note 4)		116,365		61,144
Advances and Prepaid Expenses		—		7,399
Total Intragovernmental Assets	**$**	**7,762,740**	**$**	**7,578,187**
Accounts Receivable, Net (Note 4)		49,793		3,607
Materials and Supplies (Note 5)		2,952,031		2,679,477
Property, Plant and Equipment, Net (Note 6)		34,609,217		36,624,536
Advances and Prepaid Expenses		97		5,270
Total Assets	**$**	**45,373,878**	**$**	**46,891,077**
Liabilities				
Intragovernmental Liabilities				
Accounts Payable	$	73,972	$	96,931
Other Liabilities (Note 7)		110,872		74,022
Total Intragovernmental Liabilities	**$**	**184,844**	**$**	**170,953**
Accounts Payable		2,029,570		2,144,112
Federal Employee and Veterans' Benefits		68,876		—
Environmental Cleanup (Notes 1 and 8)		986,891		1,096,109
Other Liabilities (Note 7)		397,834		458,625
Total Liabilities	**$**	**3,668,015**	**$**	**3,869,799**
Net Position				
Unexpended Appropriations	$	4,771,482	$	4,291,001
Cumulative Results of Operations		36,934,381		38,730,277
Total Net Position	**$**	**41,705,863**	**$**	**43,021,278**
Total Liabilities and Net Position	**$**	**45,373,878**	**$**	**46,891,077**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Net Cost
For the Fiscal Year Ending September 30, 2004
(In Thousands of Dollars)

		2004
Program Cost		
Science, Aeronautics, and Exploration		
Intragovernmental Costs	$	708,041
Less: Intragovernmental Earned Revenue		383,396
Intragovernmental Net Costs		324,645
Gross costs with the Public		8,271,087
Less: Earned Revenue from the Public		36,969
Net Costs with the Public		8,234,118
Total Net Cost	**$**	**8,558,763**
Space Flight Capabilities		
Intragovernmental Costs		381,764
Less: Intragovernmental Earned Revenue		233,600
Intragovernmental Net Costs		148,164
Gross costs with the Public		6,281,011
Less: Earned Revenue from the Public		33,314
Net Costs with the Public		6,247,697
Total Net Cost	**$**	**6,395,861**
Total SAE and SFC	**$**	**14,954,624**
Cost Not Assigned		
Intragovernmental Costs		(33,330)
Less: Intragovernmental Earned Revenue		(11)
Intragovernmental Net Costs		(33,319)
Gross costs with the Public (Note 12)		1,499,495
Less: Earned Revenue from the Public		(8,752)
Net Costs with the Public		1,508,247
Total Net Cost	**$**	**1,474,928**
Net Cost of Operations (Notes 1 and 11)	**$**	**16,429,552**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Net Cost
For the Fiscal Year Ending September 30, 2003
(In Thousands of Dollars)

		2003
Program Costs by Enterprise		
Human Exploration and Development of Space		
Intragovernmental Costs	$	343,440
Less: Intragovernmental Earned Revenue		221,191
Intragovernmental Net Costs		122,249
Gross costs with the Public		5,103,285
Less: Earned Revenue from the Public		26,050
Net Costs with the Public		5,077,235
Total Net Cost	**$**	**5,199,484**
Space Science		
Intragovernmental Costs		153,162
Less: Intragovernmental Earned Revenue		49,023
Intragovernmental Net Costs		104,139
Gross costs with the Public		2,655,656
Less: Earned Revenue from the Public		2,771
Net Costs with the Public		2,652,885
Total Net Cost	**$**	**2,757,024**
Earth Science		
Intragovernmental Costs		432,973
Less: Intragovernmental Earned Revenue		337,854
Intragovernmental Net Costs		95,119
Gross costs with the Public		1,185,104
Less: Earned Revenue from the Public		11,386
Net Costs with the Public		1,173,718
Total Net Cost	**$**	**1,268,837**
Biological and Physical Research		
Intragovernmental Costs		63,512
Less: Intragovernmental Earned Revenue		18,554
Intragovernmental Net Costs		44,958
Gross costs with the Public		1,308,828
Less: Earned Revenue from the Public		23,749
Net Costs with the Public		1,285,079
Total Net Cost	**$**	**1,330,037**
Aerospace Technology		
Intragovernmental Costs		97,132
Less: Intragovernmental Earned Revenue		30,627
Intragovernmental Net Costs		66,505
Gross costs with the Public		1,140,563
Less: Earned Revenue from the Public		9,699
Net Costs with the Public		1,130,864
Total Net Cost		**1,197,369**
Education Programs (formerly Academic Programs)		
Gross costs with the Public		169,562
Less: Earned Revenue from the Public		606
Net Costs with the Public		168,956
Total Net Cost	**$**	**168,956**
Other Programs		
Intragovernmental Costs		54,251
Less: Intragovernmental Earned Revenue		311
Intragovernmental Net Costs		53,940
Total Net Cost	**$**	**53,940**
Net cost of operations (Notes 11 and 14)	**$**	**11,975,647**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Changes in Net Position
For the Fiscal Years Ending September 30, 2004 and September 30, 2003
(In Thousands of Dollars)

	2004 Cumulative Results of Operations	2004 Unexpended Appropriations	2003 Cumulative Results of Operations	2003 Unexpended Appropriations
Beginning Balances	$ 38,730,277	$ 4,291,001	$ 35,759,338	$ 3,903,145
Budgetary Financing Sources				
Appropriations Received	—	15,380,228	—	15,464,165
Appropriations Used	14,815,775	(14,815,775)	14,707,384	(14,707,384)
Appropriations Transferred In/Out	—		—	(125)
Unexpended Appropriations—Adjustments	—	(83,972)	—	(368,800)
Nonexchange Revenue	15,619	—	1,049	—
Donations	1	—	6	—
Other Financing Sources				
Donations of Property	—	—	3,231	—
Transfers In/(Out) Without Reimbursement	(347,480)	—	104,620	—
Imputed Financing	149,741	—	130,296	—
Total Financing Sources	**$ 14,633,656**	**$ 480,481**	**$ 14,946,586**	**$ 387,856**
Net Cost of Operations	**$ (16,429,552)**	**$ —**	**$ (11,975,647)**	**—**
Ending Balances	**$ 36,934,381**	**$ 4,771,482**	**$ 38,730,277**	**$ 4,291,001**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Combined Statement of Budgetary Resources
For the Fiscal Years Ending September 30, 2004 and September 30, 2003
(In Thousands of Dollars)

Budgetary Resources	2004		2003	
Budgetary authority				
Appropriation Received	$	15,457,160	$	15,451,354
Net Transfers, Current Year Authority		—		(125)
Opening Balance Adjustment (Note 16)		13,141		—
Total Adjusted Appropriations Received		15,470,301		15,451,229
Unobligated balance				
Unobligated Balance, Brought Forward, October 1 (Note 16)		1,763,930		1,127,920
Spending from Offsetting Collections				
Earned				
Collected		632,069		720,031
Receivable from Federal Sources		57,700		2,617
Change in Unfilled Orders				
Advance Received		(18,904)		(32,167)
Without Advance from Federal Sources		124,582		(64,203)
Recoveries of prior year obligations, Actual		1,332,239		181,530
Permanently Not Available				
Cancellations of Expired/No-Year Accounts		(83,963)		(45,733)
Authority Unavailable Pursuant to Public Law		(91,269)		(75,258)
Total Budgetary Resources	**$**	**19,186,685**	**$**	**17,265,966**
Opening Balance Adjustment (Note 16)		43,184		—
Total Adjusted Budgetary Resources	**$**	**19,229,869**	**$**	**17,265,966**
Status of Budgetary Resources				
Obligations Incurred (Note 13)				
Direct		15,313,397		14,859,449
Reimbursable		679,067		778,297
Total Obligations Incurred	**$**	**15,992,464**	**$**	**15,637,746**
Unobligated Balance (Note 16)				
Apportioned, Currently Available		2,353,659		1,550,693
Trust Funds		3,590		3,616
Not Available, Other		822,691		73,911
Total Unobligated Balances		**3,179,940**		**1,628,220**
Status Budgetary Resources	**$**	**19,172,404**	**$**	**17,265,966**
Opening Balance Adjustment (Note 16)		57,465		—
Total Adjusted Status Budgetary Resources	**$**	**19,229,869**	**$**	**17,265,966**
Obligated Balance, Net as of October 1 (Note 16)		5,798,062		5,633,407
Obligated Balance, End of Period				
Accounts Receivable		(118,833)		(61,100)
Unfilled Customer Orders		(294,103)		9,580
Undelivered Orders		2,757,050		3,608,790
Accounts Payable		2,124,642		2,354,273
Outlays				
Disbursements		15,807,247		15,239,665
Collections		(613,164)		(687,864)
Subtotal	**$**	**15,194,083**	**$**	**14,551,801**
Less: Offsetting Receipts		1		6
Net Outlays	**$**	**15,194,082**	**$**	**14,551,795**
Opening Balance Adjustment (Note 16)		(8,011)		—
Total Adjusted Net Outlays	**$**	**15,186,071**	**$**	**14,551,795**

The accompanying notes are an integral part of this statement.

National Aeronautics and Space Administration
Consolidated Statement of Financing
For the Fiscal Years Ending September 30, 2004 and September 30, 2003
(In Thousands of Dollars)

		2004		2003
Resources Used to Finance Activities				
Budgetary Resources Obligated				
Obligations Incurred	$	15,992,464	$	15,637,746
Less: Spending authority from offsetting collections and recoveries		2,127,686		807,808
Obligations net of offsetting collections and recoveries		13,864,778		14,829,938
Less: Offsetting receipts		1		6
Net obligations	**$**	**13,864,777**	**$**	**14,829,932**
Other Resources:				
Donations of Property		—		3,231
Transfers In/Out Without Reimbursements		(347,480)		104,620
Imputed financing from costs absorbed by others		149,741		130,296
Net Other Resources Used to Finance Activities	**$**	**(197,739)**	**$**	**238,147**
Total Resources Used to Finance Activities	**$**	**13,667,038**	**$**	**15,068,079**
Resources Used to Finance Items Not Part of the Net Cost of Operations				
Change in Budgetary Resources Obligated for Goods, Services and Benefits Ordered But Not Yet Provided		(955,583)		(881,272)
Resources That Fund Expenses Recognized in Prior Periods		(293,686)		(192,455)
Budgetary Offsetting Collections and Receipts that Do Not Affect the Net Costs of Operations—Other		(13,623)		(6,631)
Opening Balance Adjustment (Note 16)		91,933		
Resources that Finance the Acquisition of Assets		(1,741,671)		(5,530,972)
Other Resources or Adjustments to Net Obligated Resources That Do Not Affect Net Cost of Operation		(347,480)		(104,745)
Total Resources Used to Finance Items Not Part of the Net Cost of Operations	**$**	**(3,260,110)**	**$**	**(6,716,075)**
Total Resources Used to Finance the Net Cost of Operations	**$**	**10,406,928**	**$**	**8,352,004**
Components of Net Cost that Will Not Require or Generate Resources in the Current Period				
Components Requiring or Generating Resources in Future Periods				
Increases in Annual Leave Liability		7,821		12,989
Increase in Exchange Revenue Receivable from the Public		(100,653)		2,254
Other		106,424		51,018
Total Components of Net Cost that will Require or Generate Resources in Future Periods	**$**	**13,592**	**$**	**66,261**
Components Not Requiring or Generating Resources				
Depreciation		5,814,834		3,348,775
Revaluation of Assets or Liabilities		(14,663)		211,574
Other		208,861		(2,967)
Total Components of Net Cost of Operations that will not Require or Generate Resources	**$**	**6,009,032**	**$**	**3,557,382**
Total Components of Net Cost of Operations that will not Require or Generate Resources in the Current Period	**$**	**6,022,624**	**$**	**3,623,643**
Net Cost of Operations (Note 1)	**$**	**16,429,552**	**$**	**11,975,647**

The accompanying notes are an integral part of this statement.

1. Summary of Accounting Policies and Operations

Reporting Entity

The National Aeronautics and Space Administration (NASA) is an independent Agency established to serve as the fulcrum for initiatives by the United States in civil space and aviation. With this responsibility, NASA is entrusted with ensuring that our programs and projects are fiscally managed and properly accounted for. In August 2004, NASA restructured from six Strategic Enterprises—Human Exploration and Development of Space, Space Science, Earth Science, Biological and Physical Research, Aerospace Technology, and Education Programs—to four Mission Directorates: Exploration Systems, Space Operations, Science, and Aeronautics Research. The transformation of NASA's organizational structure is designed to streamline the agency and position it to better implement the Vision for Space Exploration.

Additionally, the transformation also consisted of restructuring the NASA functional offices to Mission Support Offices, which includes the Office of the Chief Financial Officer (OCFO). The OCFO is responsible for all NASA financial matters, including procurement and small and disadvantaged business activities. As part of the OCFO transformation, the NASA Centers' Chief Financial Offices have been realigned to report directly to the Headquarters CFO to better address critical financial issues. The financial management of operations is the responsibility of officials at all organizational levels.

The nine NASA Centers, NASA Headquarters, and the Jet Propulsion Laboratory carry out the activities of the Mission Directorates. The Jet Propulsion Laboratory is a Federally funded Research and Development Center owned by NASA but managed by an independent contractor.

Basis of Presentation

These financial statements include the Consolidated Balance Sheet as of September 30, 2004 and September 30, 2003, the related Consolidated Statement of Net Cost, Consolidated Statement of Changes in Net Position, Combined Statement of Budgetary Resources, and the Consolidated Statement of Financing for the fiscal years ended September 30, 2004 and September 30, 2003, respectively, as required by the *Chief Financial Officers Act of 1990* and the *Government Management Reform Act of 1994*.

The financial statements were prepared from the NASA Integrated Financial Management system (SAP) and other Treasury reports, in accordance with Generally Accepted Accounting Principles and accounting policies and practices summarized in this note. These financial statements were prepared under the accrual basis of accounting, where expenses and revenues are recorded in the period in which they are incurred or earned, respectively except as related to corrections of prior year data.

The Statement of Net Cost is presented on a non-comparative appropriation basis due to the organizational transformation that occurred in August 2004 of six Strategic Enterprises to four Mission Directorates. The related notes require a detailed breakdown by mission directorates, which was not available due to the late year transformation. The statement of net cost presents the Space Flight Capabilities, and Science, Aeronautics, and Exploration separately, with all remaining items reported as costs not assigned.

Budgets and Budgetary Accounting

NASA is funded by three appropriations, which require individual treatment for accounting and control purposes. The financial management system, SAP, does not prevent cross-appropriation financial postings. NASA has identified instances of cross-appropriation postings that created out-of-balance appropriations. Some cross-appropriations and out-of-balance conditions were still being researched at year-end.

Reimbursements to appropriations total approximately $678 and $732 million for fiscal years 2004 and 2003, respectively. As part of its reimbursable program, NASA launches devices into space and provides tracking and data relay services for the U.S. Department of Defense, the National Oceanic and Atmosphere Administration, and the National Weather Service.

On the Statement of Budgetary Resources, Unobligated Balances—Available should represent the amount remaining in accounts that are available for obligation in future fiscal years. Unobligated Balances—Not Available should represent the amount remaining in appropriation accounts that can only be used for adjustments to previously recorded obligations. The amount reported for Recovery of Prior Year Obligations, approximately $1.3 billion for FY 2004, is overstated. The financial system has limited functionality that could not be configured before year-end to capture the proper data for Recovery of Prior Year Obligations. The functionality also created misstatements in other budgetary accounts including Unobligated Balances—Available.

Use of Estimates

The preparation of financial statements requires management to make estimates and assumptions that affect the reported amounts of assets and liabilities as of the date of the financial statements and the reported amounts of revenues and expenses during the reporting period. Actual results could differ from these estimates.

Fund Balance with Treasury

Treasury processes cash receipts and disbursements for NASA. Fund Balance with Treasury includes appropriated funds, trust funds, deposit funds, and budget clearing accounts.

Investments in U.S. Government Securities

Intragovernmental non-marketable securities includes the following investments:

- The National Aeronautics and Space Administration Endeavor Teacher Fellowship Trust Fund established from public donations in tribute to the crew of the Space Shuttle Challenger, and

- The Science Space and Technology Education Trust Fund established for programs to improve science and technology education.

Accounts Receivable

Most receivables are for reimbursement of research and development costs related to satellites and launch services. The allowance for uncollectible accounts is based upon evaluation of public accounts receivable, considering the probability of failure to collect based upon current status, financial and other relevant characteristics of debtors, and the relationship with the debtor. Under a cross-servicing arrangement, public accounts receivables over 180 days delinquent are turned over to Treasury for collection. The receivable remains on NASA's books until Treasury determines the receivable is uncollectible.

Prepaid Expenses

Payments in advance of receipt of goods or services are recorded as prepaid expenses at the time of payment and recognized as expenses when related goods or services are received.

Materials and Supplies

Materials held by Centers and contractors that are repetitively procured, stored and issued on the basis of demand are considered Materials and Supplies. Certain NASA contractors' inventory management systems do not distinguish between items that should be classified as materials and those that should be classified as depreciable property. NASA reclassifies as property, all materials valued at $100,000 or greater that support large-scale assets such as the Space Shuttle and the International Space Station.

Property, Plant and Equipment

The Agency and its contractors and grantees hold NASA-owned property, plant, and equipment. Property with a unit cost of $100,000 or more and a useful life of two years or more is capitalized; all other property is expensed when purchased. Capitalized costs include all costs incurred by NASA to bring the property to a form and location suitable for its intended use. Under provisions of the Federal Acquisition Regulation (FAR), contractors are responsible for control over accountability for government-owned property in their possession. NASA's contractors and grantees report on NASA property in their custody annually and its top contractors monthly.

In FY 2003, the accounting treatment for capitalization of Theme Assets was expanded to include all costs. In previous years, NASA expensed certain components of these types of assets that did not meet the capitalization criteria (useful life less than two years). In order to properly match outputs to inputs, NASA's policy was changed to capture certain components of these assets as Work in Progress (WIP) and then expense the costs in their year of operation.

Capitalized costs for internally developed software included the full costs (direct and indirect) incurred during the software development stage only. For purchased software, capitalized costs include amounts paid to vendors for the software and material internal costs incurred by the Agency to implement and make the software ready for use through acceptance testing. When NASA purchases software as part of a package of products and services (for example: training, maintenance, data conversion, reengineering, site licenses, and rights to future upgrades and enhancements), capitalized and non-capitalized costs of the package are allocated among individual elements on the basis of a reasonable estimate of their relative fair market values. Costs that are not susceptible to allocation between maintenance and relatively minor enhancements are expensed. NASA capitalizes costs for internal use software when the total projected cost is $1,000,000 or more and the expected useful life of the software is two years or more.

These financial statements report depreciation expense using the straight-line method. Useful lives are 40 years for buildings; 15 years for other structures and facilities; 15 years for leasehold improvements, 15 years for space hardware; seven years for special test equipment and tooling; and five to 20 years for other equipment depending on its nature. Useful lives for the Shuttle fleet range from 28 to 39 years. Useful lives for theme assets are their mission lives, ranging from two to 20 years.

International Space Station

NASA began depreciating the Station in FY 2001 when occupied by the first permanent crew. Only the Station's major elements in space are depreciated; any on-ground elements are reported as work in process until launched and incorporated into the existing Station structure. In FY 2003, NASA management changed the Station's operational life from 10 years to 15 years. The depreciation expense for FY 2004 was $965 million and the depreciation expense for FY 2003 was $929 million.

On January 14, 2004, President Bush announced a new vision for the Nation's space exploration program. Implementation of this initiative has required NASA to prioritize and restructure existing programs and missions, and to phase out sooner than originally planned, or eliminate all together over the next several years, some programs and missions. These programs and missions include the Shuttle, which was originally planned to continue to the year 2020 but now will retire as soon as assembly of the International Space Station is completed (planned for the end of this decade), and the possible cancellation of planned servicing missions to the Hubble Space Telescope.

Barter Transactions

NASA utilizes non-monetary transactions in the form of barter agreements with International Partners that govern the reciprocal exchange of goods and services. The Station international agreements are committed to minimize the exchange of funds among partners, by utilizing non-monetary transactions in the form of barter agreements with International Partners. NASA's policy is to record barter transactions based upon the fair value of the non-monetary assets transferred to or from an enterprise, whichever is more readily determinable. Fair value is determined by referring to estimated realizable values in cash transactions of the same or similar assets, quoted market prices, independent appraisals, estimated fair value market prices, independent appraisals, estimated fair values of assets or services received in exchange, and other available evidence. If fair value is not readily determinable within reasonable limits, no value is ascribed to the non-monetary transactions in accordance with Accounting Principles Bulletin No. 29, Accounting for Non-monetary Transactions. When fair value is readily determinable, barter transactions are recorded as an asset to Government-Held/Government-Owned Equipment with a corresponding liability to Liability for Assets Obtained Under Barter Agreements.

Advances from Others

Advances from Others represents amounts advanced by other Federal and non-Federal entities for goods or services to be provided and are included in other liabilities in the Financial Statements.

Liabilities Covered by Budgetary Resources

Liabilities covered by budgetary resources are liabilities that are covered by realized budgetary resources as of the balance sheet date. Realized budgetary resources include new budget authority, unobligated balances of budgetary resources at the beginning of the year, and spending authority from offsetting collections. Examples include accounts payable, and salaries.

Accounts Payable includes amounts recorded for the receipt of goods or services furnished. Additionally, NASA accrues costs and recognizes liabilities based on information provided monthly by contractors on Contractor Financial Management Reports (NASA Forms 533M and 533Q). DCAA performs independent audits to ensure reliability of reported costs and estimates. To provide further assurance, financial managers are required to test the accuracy of NF 533 generated cost accruals each month, and NASA Headquarters independently analyzes the validity of Centers' data.

Liabilities and Contingencies Not Covered by Budgetary Resources

Generally liabilities not covered by budgetary resources are liabilities for which Congressional action is needed before budgetary resources can be provided. Examples include the *Federal Employees' Compensation Act* (FECA) actuarial liability and contingencies.

Liabilities not covered by budgetary resources include certain environmental matters, legal claims, pensions and other retirement benefits (ORB), workers' compensation, annual leave, and closed appropriations.

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Liabilities not covered by budgetary resources consist primarily of environmental cleanup costs as required by Federal, state, and local statutes and regulations. Where up-to-date, site-specific engineering estimates for cleanup are not available, NASA employs commercially available parametric modeling software to estimate the total cost of cleaning up known contamination at these sites over future years. NASA estimates the total cost of environmental cleanup to be $986 million and $1,097 million for the fiscal years ended September 30, 2004 and September 30, 2003, respectively, and recorded an unfunded liability in its financial statements for this amount. This estimate could change in the future due to identification of additional contamination, inflation, deflation, and changes in technology or applicable laws and regulations. NASA believes the estimated environmental liability could range from $656 million to $1.5 billion because of potential future changes to the engineering assumptions underlying the estimates. The estimate represents an amount that will be spent to remediate currently known contamination, subject to the availability of appropriated funds. Other responsible parties that may be required to contribute to the remediation funding could share this liability. NASA was appropriated $84 million and $92 million for the fiscal years ended September 30, 2004 and September 30, 2003, respectively, for environmental compliance and restoration.

NASA is a party in various administrative proceedings, court actions (including tort suits), and claims brought by or against it. In the opinion of management and legal counsel, the ultimate resolution of these proceedings, actions and claims will not materially affect the financial position, net cost, changes in net position, budgetary resources, or financing of NASA. Liabilities have been recorded for $36 million and $1 million for these matters as of September 30, 2004 and September 30, 2003, respectively.

No balances have been recorded in the financial statements for contingencies related to proceedings, actions, and claims where management and legal counsel believes that it is possible but not probable that some costs will be incurred. These contingencies range from zero to $127 million and from zero to $50 million, as of September 30, 2004 and September 30, 2003.

A liability for $85 million and $84 million was recorded, as of September 30, 2004 and September 30, 2003, respectively, for workers' compensation claims related to FECA, administered by the U.S. Department of Labor. FECA provides income and medical cost protection to covered Federal civilian employees injured on the job, employees who have incurred a work-related occupational disease, and beneficiaries of employees whose death is attributable to a job-related injury or occupational disease. The FECA program initially pays valid claims and subsequently seeks reimbursement from the Federal agencies employing the claimants. The FECA liability includes the actuarial liability of $69 million for estimated future costs of death benefits, workers' compensation, and medical and miscellaneous costs for approved compensation cases. The present value of these estimates at the end of FY 2004 was calculated by the Department of Labor using a discount rate of 4.883 percent for FY 2004. This liability does not include the estimated future costs for claims incurred but not reported or approved as of September 30, 2004.

NASA has recorded approximately $83 million in Accounts Payable related to closed appropriations for which there are contractual commitments to pay. These payables will be funded from appropriations available for obligation at the time a bill is processed, in accordance with Public Law 101-510.

Annual, Sick, and Other Leave

Annual leave is accrued as it is earned; the accrual is reduced as leave is taken. Each year, the balance in the accrued annual leave account is adjusted to reflect current pay rates. To the extent current or prior year appropriations are not available to fund annual leave earned but not taken, funding will be obtained from future financing sources. Sick leave and other types of non-vested leave are expensed as taken.

Employee Benefits

Agency employees participate in the Civil Service Retirement System (CSRS), a defined benefit plan, or the Federal Employees Retirement System (FERS), a defined benefit and contribution plan. For CSRS employees, NASA makes contributions of 8.51 percent of pay. For FERS employees, NASA makes contributions of 10.7 percent to the defined benefit plan, contributes 1 percent of pay to a retirement saving plan (contribution plan), and matches employee contributions up to an additional four percent of pay. For FERS employees, NASA also contributes to employer's matching share for Social Security.

Statement of Federal Financial Accounting Standards No. 5, "Accounting for Liabilities of the Federal Government," require government agencies to report the full cost of employee benefits (FEHB), and the Federal Employees Group Life Insurance (FEGLI) Programs. NASA used the applicable cost factors and imputed financing sources from the Office of Personnel and Management Letter For Chief Financial Officers, dated August 16, 2004, in these financial statements.

2. Fund Balance with Treasury

(In Thousands of Dollars)

	September 30, 2004		
Fund Balances	Entity	Non-Entity	Total
Appropriated Funds	$ 7,645,106	$ —	$ 7,645,106
Trust Funds	—	3,592	3,592
Other Fund Types	(19,400)	—	(19,400)
Total	$ 7,625,706	$ 3,592	$ 7,629,298

NASA reformatted the display of note 2 for FY 2004 to better align with the Office of Management and Budget, Bulletin 01-09, Form and Content of Agency Financial Statements. The second part of the note related to opening balances could not be prepared as discussed in Note 16.

	September 30, 2003			
Fund Balances	Obligated	Unobligated—Available	Unobligated—Not Available	Total
Appropriated Funds	$ 5,911,543	$ 1,550,693	$ 73,911	$ 7,536,147
Trust Funds	—	—	3,616	3,616
Total	$ 5,911,543	$ 1,550,693	$ 77,527	$ 7,539,763
Clearing and Deposit Accounts				(47,257)
Total Fund Balance with Treasury				$ 7,492,506

Obligated balances represent the cumulative amount of obligations incurred, including accounts payable and advances from reimbursable customers, for which outlays have not yet been made. Unobligated available balances represent the amount remaining in appropriation accounts that are available for obligation in the next fiscal year. Unobligated balances not available represent the amount remaining in appropriation accounts that can be used for adjustments to previously recorded obligations. Unobligated balances not available are the result of settling obligated balances for less than what was obligated. Unobligated trust fund balances not available represent amounts that must be apportioned by the OMB before being used to incur obligations.

Clearing accounts are used for unidentified remittances presumed to be applicable to budget accounts but are being held in the clearing account because the specific appropriation account is not yet known. Deposit account balances represent amounts withheld from employees' pay for U.S. Savings Bonds and state tax withholdings that will be transferred in the next fiscal year.

3. Investments

(In Thousands of Dollars)

	September 30, 2004				
	Par Value	Amortization Method	Discounts and Premiums, Net	Interest Receivable	Net Amount Invested
Intragovernmental Non-Marketable Securities	$ 14,067	Interest Method	$ 2,862	$ 148	$ 17,077

	September 30, 2003				
	Par Value	Amortization Method	Discounts and Premiums, Net	Interest Receivable	Net Amount Invested
Intragovernmental Non-Marketable Securities	$ 13,942	Interest Method	$ 3,050	$ 146	$ 17,138

Intragovernmental securities are non-marketable Treasury securities issued by the Bureau of Public Debt.

Effective interest rates range from 0.846 percent to 6.6 percent and from 0.876 percent to 5.262 percent for the fiscal year ended September 30, 2004 and September 30, 2003, respectively.

The interest method was used to amortize discounts and premiums.

4. Accounts Receivable, Net

(In Thousands of Dollars)

	September 30, 2004		
	Accounts Receivable	Allowance for Uncollectible Accounts	Net Amount Due
Intragovernmental	$ 116,365	$ —	$ 116,365
Public	50,591	(798)	49,793
Total	$ 166,956	$ (798)	$ 166,158

	September 30, 2003		
	Accounts Receivable	Allowance for Uncollectible Accounts	Net Amount Due
Intragovernmental	$ 61,144	$ —	$ 61,144
Public	4,492	(885)	3,607
Total	$ 65,636	$ (885)	$ 64,751

5. Operating Materials and Supplies

(In Thousands of Dollars)

	September 30, 2004	
	2004	2003
Operating Materials and Supplies, Held for Use	$ 2,948,792	$ 2,676,245
Operating Materials and Supplies, Held in Reserve for Future Use	3,239	3,232
Total	$ 2,952,031	$ 2,679,477

Operating Materials and Supplies, Held for Use are tangible personal property held by NASA and its contractors to be used for fabricating and maintaining NASA assets. They will be consumed in normal operations. Operating Materials and Supplies, Held in Reserve for Future Use are tangible personal property held by NASA for emergencies for which there is no normal recurring demand but that must be immediately available to preclude delay, which might result in loss, damage, or destruction of government property, danger to life or welfare of personnel, or substantial financial loss to the government due to an interruption of operations. All materials are valued using historical costs, or other valuation methods that approximate historical cost. NASA Centers and contractors are responsible for continually reviewing materials and supplies to identify items no longer needed for operational purposes or that need to be replaced. Excess, obsolete, and unserviceable items have been removed from these amounts. There are no restrictions on these items.

6. Property, Plant, and Equipment, Net

(In Thousands of Dollars)

	September 30, 2004		
	Cost	Accumulated Depreciation	Net Asset Value
Government-owned/Government-held			
Land	$ 115,132	$ —	$ 115,132
Structures, Facilities, and Leasehold Improvements	5,305,594	(3,839,144)	1,466,450
Theme Assets	40,456,990	(22,450,519)	18,006,471
Equipment	2,018,816	(1,338,509)	680,307
Capitalized Leases (Note 10)	4,920	(316)	4,604
Internal Use Software and Development	31,839	(9,957)	21,882
Work-in-Process (WIP)	5,808,684	—	5,808,684
Total	**$ 53,741,975**	**$ (27,638,445)**	**$ 26,103,530**
Government-owned/Contractor-held			
Land	$ 8,076	$ —	$ 8,076
Structures, Facilities, and Leasehold Improvements	801,131	(542,559)	258,572
Equipment	9,947,438	(7,862,657)	2,084,781
Work-in-Process	6,154,258	—	6,154,258
Total	**16,910,903**	**(8,405,216)**	**8,505,687**
Total Property, Plant, and Equipment	**$ 70,652,878**	**$ (36,043,661)**	**$ 34,609,217**

	September 30, 2003		
	Cost	Accumulated Depreciation	Net Asset Value
Government-owned/Government-held			
Land	$ 115,132	$ —	$ 115,132
Structures, Facilities, and Leasehold Improvements	5,575,501	(3,852,518)	1,722,983
Theme Assets	36,003,528	(18,105,281)	17,898,247
Equipment	1,926,673	(1,278,218)	648,455
Capitalized Leases (Note 10)	273	(59)	214
Internal Use Software and Development	22,600	(4,473)	18,127
Work-in-Process (WIP)	8,119,053	—	8,119,053
Total	**$ 51,762,760**	**$ (23,240,549)**	**$ 28,522,211**
Government-owned/Contractor-held			
Land	$ 8,076	$ —	$ 8,076
Structures, Facilities, and Leasehold Improvements	755,344	(502,054)	253,290
Equipment	9,940,395	(7,408,231)	2,532,164
Work-in-Process	5,308,795	—	5,308,795
Total	**16,012,610**	**(7,910,285)**	**8,102,325**
Total Property, Plant, and Equipment	**$ 67,775,370**	**$ (31,150,834)**	**$ 36,624,536**

Theme Assets are property, plant and equipment specifically designed for use in a NASA program. Equipment includes special tooling, special test equipment, and Agency-peculiar property, such as the Shuttle and other configurations of spacecraft (engines, unlaunched satellites, rockets, and other scientific components) unique to NASA space programs. Structures, Facilities, and Leasehold Improvements includes buildings with collateral equipment, and capital improvements, such as airfields, power distribution systems, flood control, utility systems, roads, and bridges. NASA also has use of certain properties at no cost. These properties include land at the Kennedy Space Center withdrawn from the public domain and land and facilities at the Marshall Space Flight Center under a no cost, 99-year lease with the U.S. Department of the Army. Work-in-Process is the cost incurred for property, plant, and equipment items not yet completed. Work-in-Process includes equipment and facilities that are being constructed. WIP includes the fabrication of assets that may or may not be capitalized once completed and operational. If it is determined to not meet capitalization criteria (i.e., less than two years useful life) the project will be expensed to the Statement of Net Cost to match outputs to inputs.

NASA has Station bartering agreements with international agencies including the European Space Agency and the National Space Agency of Japan. NASA barters with these other space agencies to obtain Station hardware elements in exchange for providing goods and services such as Space Shuttle transportation and a share of NASA's Station utilization rights. The intergovernmental agreements state that the parties will seek to minimize the exchange of funds in the cooperative program, including the use of barters to provide goods and services. As of September 30, 2004, NASA has received some assets from these parties in exchange for future services. However, due to the fact that fair value is indeterminable, no value was ascribed to these transactions in accordance with APB No. 29. Under all agreements to date, NASA's Station Program's International Partners Office expects that NASA will eventually receive future NASA-required elements as well with no exchange of funds.

NASA reports the physical existence (in terms of physical units) of heritage assets as part of the required supplemental stewardship information.

7. Other Liabilities

(In Thousands of Dollars)

	September 30, 2004		
	Current	Non-Current	Total
Intragovernmental Liabilities			
Advances From Others	$ 90,568	$ —	$ 90,568
Workers' Compensation	6,854	8,933	15,787
Employer Contributions and Payroll Taxes	440	—	440
Liability for Deposit and Clearing Funds	781	—	781
Custodial Liability	2,082	—	2,082
Lease Liabilities	—	—	—
Other Liabilities	1,214	—	1,214
Contract Holdbacks	—	—	—
Other Accrued Liabilities	—	—	—
Subtotal	101,939	8,933	110,872
Accounts Payable for Closed Appropriations	947	3,042	3,989
Total Intragovernmental	**$ 102,886**	**$ 11,975**	**$ 114,861**
Liabilities from the Public			
Unfunded Annual Leave	$ —	$ 166,448	$ 166,448
Employer Contributions and Payroll Taxes	14,324	—	14,324
Accrued Funded Payroll	59,037	—	59,037
Advances From Others	82,838	—	82,838
Contract Holdbacks	2,509	—	2,509
Custodial Liability	(2,082)	—	(2,082)
Other Accrued Liabilities	21,438	—	21,438
Contingent Liabilities	—	36,205	36,205
Lease Liabilities	2,255	—	2,255
Liability for Deposit and Clearing Funds	9,189	—	9,189
Other Liabilities	5,673	—	5,673
Subtotal	195,181	202,653	397,834
Accounts Payable for Closed Appropriations	34,746	44,560	79,306
Actuarial FECA Liability	—	68,876	68,876
Total Liabilities from the Public	**$ 229,927**	**$ 316,089**	**$ 546,016**
Total Other Liabilities	**$ 332,813**	**$ 328,064**	**$ 660,877**

7. Other Liabilities (Continued)
(In Thousands of Dollars)

	September 30, 2003		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Advances From Others	$ 50,242	$ —	$ 50,242
Workers' Compensation	8,470	6,854	15,324
Accrued Funded Payroll	6,362	—	6,362
Accounts Payable for Closed Appropriations	—	32	32
Liability for Deposit and Clearing Funds	6	—	6
Custodial Liability	2,056	—	2,056
Lease Liabilities	—	—	—
Total Intragovernmental Liabilities	**$ 67,136**	**$ 6,886**	**$ 74,022**
Liabilities from the Public:			
Unfunded Annual Leave	$ —	$ 158,627	$ 158,627
Accrued Funded Payroll	61,623	—	61,623
Actuarial FECA Liability	—	69,446	69,446
Accounts Payable for Closed Appropriations	1,649	31,328	32,977
Advances From Others	142,294	—	142,294
Contract Holdbacks	1,680	—	1,680
Custodial Liability	280	—	280
Other Accrued Liabilities	38,029	—	38,029
Contingent Liabilities	—	1,023	1,023
Lease Liabilities	100	—	100
Liability for Deposit and Clearing Funds	(47,454)	—	(47,454)
Total Liabilities from the Public	**$ 198,201**	**$ 260,424**	**$ 458,625**
Total Other Liabilities	**$ 265,337**	**$ 267,310**	**$ 532,647**

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8. Liabilities Not Covered by Budgetary Resources
(In Thousands of Dollars)

	September 30, 2004		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Workers' Compensation	$ 6,854	$ 8,933	$ 15,787
Accounts Payable for Closed Appropriations	947	3,042	3,989
Total Intragovernmental	**$ 7,801**	**$ 11,975**	**$ 19,776**
From the Public:			
Environmental Cleanup Costs	—	986,891	986,891
Unfunded Annual Leave	—	166,448	166,448
Actuarial FECA Liability	—	68,876	68,876
Contingent Liabilities	—	36,205	36,205
Subtotal	—	1,258,420	1,258,420
Accounts Payable for Closed Appropriations	34,746	44,560	79,306
Total from the Public	**34,746**	**1,302,980**	**1,337,726**
Total Liabilities Not Covered by Budgetary Resources	**$ 42,547**	**$ 1,314,955**	**$ 1,357,502**

	September 30, 2003		
	Current	Non-Current	Total
Intragovernmental Liabilities:			
Workers' Compensation	$ 8,470	$ 6,854	$ 15,324
Accounts Payable for Closed Appropriations	—	32	32
Total Intragovernmental	**8,470**	**6,886**	**15,356**
From the Public:			
Environmental Cleanup Costs	—	1,096,109	1,096,109
Unfunded Annual Leave	—	158,627	158,627
Actuarial FECA Liability	—	69,446	69,446
Accounts Payable for Closed Appropriations	1,649	31,328	32,977
Contingent Liabilities	—	1,023	1,023
Total From the Public	**1,649**	**1,356,533**	**1,358,182**
Total Liabilities Not Covered by Budgetary Resources	**$ 10,119**	**$ 1,363,419**	**$ 1,373,538**

See Note 1 for further discussion of liabilities not covered by budgetary resources.

National Aeronautics and Space Administration
Notes to Financial Statements

9. Non-Entity Assets
(In Thousands of Dollars)

	September 30, 2004		
	Intragovernmental	Due from the Public	Total Non-Equity Assets
Accounts Receivable, Net	**$ 2,082**	**$ (2,082)**	**$ —**

Based on a review of FY 2004 transactions reported in custodial activity, NASA determined the transactions did not represent custodial activity.

	September 30, 2003		
	Intragovernmental	Due from the Public	Total Non-Equity Assets
Accounts Receivable, Net	**$ 2,056**	**$ 3,229**	**$ 5,285**

Accounts receivable related to closed appropriations, which will be deposited in miscellaneous receipts, are included in Non-Entity Assets. These amounts represent NASA's custodial activity and are not separately identified on the Balance Sheet as the amounts are immaterial.

10. Leases
(In Thousands of Dollars)

	As of September 30	
Capital Leases–Summary of Assets Under Capital Lease	2004	2003
Equipment	$ 4,920	$ 273
Accumulated Amortization of Liability	(2,665)	(173)
	$ 2,255	**$ 100**

Capital leases consist of various types of computer equipment with non-cancelable terms longer than one year, a fair market value of $100,000 or more, a useful life of two years or more, and agreement terms equivalent to an installment purchase. The increase from 2003 to 2004 was due to the receipt of two new leases.

Future Minimum Lease Payments	
Fiscal Year	
2005	$ 2,092
2006	267
2007	—
2008 and After	—
Future Lease Payments	2,359
Less: Imputed Interest	(104)
Net Capital Lease Liability	**$ 2,255**
Lease Liabilities Covered by Budgetary Resources	$ 2,255
Lease Liabilities Not Covered by Budgetary Resources	—
Total Lease Liabilities	**$ 2,255**

10. Leases (Continued)
(In Thousands of Dollars)

Operating Leases

Operating leases includes those leases that are not capital leases and are for a non-cancelable period in excess of one year. NASA's FY 2004 operating leases are for an airplane hangar, warehouse storage, copiers, office trailers, and land.

Future Minimum Lease Payments

	Land and Buildings		Equipment		Total	
2005	$	691	$	12,051	$	12,742
2006		14		11,314		11,328
2007		14		8,665		8,679
2008		14				14
2009 and After		—		—		—
Total Future Lease Payments	**$**	**733**	**$**	**32,030**	**$**	**32,763**

Entity as Lessor

Operating Leases

Future Projected Receipts

Fiscal Year	Land and Buildings	
2005	$	423
2006		372
2007		351
2008		347
2009 and After		803
Total Future Operating Lease Receivables	**$**	**2,296**

NASA leases and allows use of its land and facilities by the public and other government entities for a fee.

11. Gross Cost and Earned Revenue By Budget Functional Classification

(In Thousands of Dollars)

Functional Classification	Gross Cost	Earned Revenue	Net Cost
	For the Period Ending September 30, 2004		
General Science, Space, and Technology	$ —	$ —	$ —
Transportation			
Research and General Education Aids	—	—	—
Total	**$ 17,108,068**	**$ (678,516)**	**$ 16,429,552**

The breakdown by budget sub-function was not available for FY 2004. The budget sub-function code was not configured in SAP at the beginning of the fiscal year, so most transaction were posted without the budget sub-function code.

Functional Classification	Gross Cost	Earned Revenue	Net Cost
	For the Period Ending September 30, 2003		
General Science, Space, and Technology	$ 12,537,907	$ (731,216)	$ 11,806,691
Transportation	169,562	(606)	168,956
Research and General Education Aids	—	—	—
Total	**$ 12,707,469**	**$ (731,822)**	**$ 11,975,647**

12. Statement of Net Cost

(In Thousands of Dollars)

Costs not Assigned to Space Flight Capabilities or Science, Aeronautics, and Exploration

	Fiscal Year 2004
Property, Plant, and Equipment	$ 2,444,722
Office of Inspector General	25,874
Other	(995,668)
Total	**$ 1,474,928**

The Statement of Net Cost recognizes post-employment benefit expenses of $252 million and $130 million for fiscal years 2004 and 2003, respectively.

The expense to Office of Personnel Management represents NASA's share of current and estimated future outlays for employee pensions, life and health insurance. Additionally, the statement includes $936 thousand and $630 thousand for fiscal years 2004 and 2003, respectively, for the Judgment Fund. The expense attributable to Treasury's Judgment Fund represents amounts paid directly from the Judgment Fund.

13. Statement of Budgetary Resources

(In Thousands of Dollars)

Apportionment Categories of Obligations Incurred

The amounts of direct and reimbursable obligations incurred against amounts apportioned under Categories A and B are displayed below:

	Direct	Reimbursable	Total
2004	$ 15,313,397	$ 679,067	$ 15,992,464
2003	$ 14,859,449	$ 778,297	$ 15,637,746

The amounts of obligations incurred against amounts apportioned under Category A are $1,000.

NASA compared the amounts reported the Statement of Budgetary Resources and the actual amounts reported in the Budget of the United States Government as required by SFFAS No. 7 for FY 2003 and identified no material differences.

The Budget of the United States Government with actual amounts for FY 2004 was not published as of November 15, 2004. The comparison for FY 2004 will be performed when the Budget of the United States Government is published.

National Aeronautics and Space Administration
Notes to Financial Statements

14. Net Cost by Program
(In Thousands of Dollars)

Fiscal Year 2004

In August 2004, NASA restructured from six Strategic Enterprises—Human Exploration and Development of Space, Space Science, Earth Science, Biological and Physical Research, Aerospace Technology, and Education Programs to four Mission Directorates—Exploration Systems, Space Operations, Science, and Aeronautics Research.

The Statement of Net Cost is presented on a non-comparative basis due to the organizational transformation that occurred in August 2004 of six Strategic Enterprises to four Mission Directorates. This note requires a detailed breakdown by mission directorates, which was not available due to the late year transformation.

Program/Operating Expenses by Enterprise

		2003
Human Exploration and Development of Space		
Space Shuttle	$	3,008,611
Space Station		1,510,049
Space Operations		69,342
Investment and Support		145,031
Payload Utilization and Operations		217,999
Mission Communications Services		(46,608)
Space Communications Services		295,008
U.S./Russian Cooperative		52
Total Human Exploration and Development of Space	**$**	**5,199,484**
Space Science		
Space Science	**$**	**2,757,024**
Earth Science		
Earth Science	**$**	**1,268,837**
Biological and Physical Research		
Biological and Physical Research	**$**	**1,330,037**
Aerospace Technology		
Aerospace Technology		1,083,956
Advanced Space Transportation		5,533
Commercial Technology		107,880
Total Aerospace Technology	**$**	**1,197,369**
Education (formerly Academic Programs)		
Education		168,956
Total Enterprise Program Costs	**$**	**11,921,707**
Costs Not Assigned to Enterprises		
Other Programs		53,940
Total Costs Not Assigned to Enterprises	**$**	**53,940**
Net Cost of Operations	**$**	**11,975,647**

Depreciation expenses in the amount of $3,348,775 for FY 2003 has been allocated to the applicable programs based on percentage of current year labor hours per project. Capitalized costs in the amount of $5,530,942 for FY 2003 has been allocated to the applicable programs based on percentage of current year labor hours per project.

15. Explanation of the Relationship Between Liabilities Not Covered by Budgetary Resources on the Balance Sheet and the Change in Components Requiring or Generating Resources in Future Periods

Liabilities Not Covered by Budgetary Resources of $1,357,502 and $1,373,538 for fiscal years 2004 and 2003, respectively, represent NASA's environmental liability, FECA liability to DOL and employees, contingent liabilities, accounts payable for closed appropriations and leave earned but not taken (See Note 8, Liabilities Not Covered by Budgetary Resources). Only a portion of these liabilities will require or generate resources in future periods.

16. General Information

During FY 2003, NASA replaced ten disparate accounting systems and over 120 ancillary subsystems that had been in operation at our Centers for the past two decades with a commercial off-the-shelf, Agency-wide, Integrated Financial Management system (SAP Core Financials application module). In meeting our goal of having one Agency-wide financial system, FY 2004 is the first full year in which the SAP Core Financial system was used by all NASA activities, providing the opportunity to produce consolidated financial statements and other Agency-wide reports directly from SAP. Although much progress has been made in improving our financial systems processes, the Agency has had some significant system conversion and data integrity challenges that we are aggressively identifying and resolving.

NASA closed FY 2003 with a number of known data integrity issues that were corrected during FY 2004. The correction of prior year transactions resulted in the misstatement of many budgetary and proprietary nominal accounts, as the financial management system could not distinguish between current transactions and corrections to prior year transactions posted in the current year.

The data integrity issues from FY 2003 resulted in the opening balances in many budgetary and proprietary accounts being misstated when FY 2004 opened. Correct FY 2004 beginning balances could not be established in SAP, as the system could not distinguish between current transactions and corrections to prior year transactions posted in the current year. The existing opening balances in SAP could not be updated for prior correction activity.

The configuration and data integrity issues from FY 2003 and during FY 2004 caused misstatements in accounts that contained trading partner data. This limited NASA's ability to reconcile and resolve differences with trading partners (other Federal agencies) and eliminate intra-entity transactions (activity between Centers).

During a review of a depreciation calculation, an error of approximately $200 million was discovered that caused an overstatement of depreciation expense for FY 2004. There was not sufficient time to accurately record an adjustment and re-produce the financial statements.

Through various internal control procedures, NASA identified anomalies and abnormalities that were being researched when the fiscal year closed. These items caused misstatements in many budgetary and proprietary accounts. NASA will continue to aggressively research, document, and resolve these items during FY 2005.

NASA identified functionality and configuration issues in SAP that created inappropriate transactional postings, which resulted in abnormal balances and misstatement of other balances. In some cases, the functionality or configuration issues could only be corrected at the beginning of a fiscal year, or when additional functionality is provided by SAP Corporation. In other cases, SAP has limited functionality that could not be configured to capture the proper data. Many of the transactional corrections for these items were accomplished during FY 2004.

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Heritage Assets
For the Fiscal Year Ended September 30, 2004

Federal agencies are required to classify and report heritage assets, in accordance with the requirements of SFFAS No. 8, "Supplementary Stewardship Reporting."

Heritage Assets are property, plant, and equipment that possess one or more of the following characteristics: historical or natural significance; cultural, educational, or aesthetic value; or significant architectural characteristics.

Since the cost of heritage assets is usually not determinable, NASA does not place a value on them or establish minimum value thresholds for designation of property, plant, or equipment as heritage assets. Additionally, the useful lives of heritage assets are not reasonably estimable for depreciation purposes. Since the most relevant information about heritage assets is their existence, they are qualified in terms of physical units, as follows:

	2003	Additions	Withdrawals	2004
Buildings and Structures	40	—	4	36
Air and Space Displays and Artifacts	540	9	53	496
Art and Miscellaneous items	1,017	4	5	1,016
Total Heritage Assets	**1,597**	**13**	**62**	**1,548**

Heritage Assets were generally acquired through construction by NASA or its contractors, and are expected to remain in this category, except where there is legal authority for transfer or sale. Heritage assets are generally in fair condition, suitable only for display.

Many of the buildings and structures are designated as National Historic Landmarks. Numerous air and spacecraft and related components are on display at various locations to enhance public understanding of NASA programs. NASA eliminated their cost from its property records when they were designated as heritage assets. A portion of the amount reported for deferred maintenance is for heritage assets.

For more than 30 years, the NASA Art Program has documented America's major accomplishments in aeronautics and space. During that time, more than 200 artists have generously contributed their time and talent to record their impressions of the U.S. Aerospace Program in paintings, drawings, and other media. Not only do these art works provide a historic record of NASA projects, they give the public a new and fuller understanding of advancements in aerospace. Artists are, in fact, given a special view of NASA through the "back door." Some have witnessed astronauts in training or scientists at work. The art collection, as a whole, depicts a wide range of subjects, including Shuttle launches, aeronautics research, the Hubble Space Telescope, and even virtual reality.

Artists commissioned by NASA receive a small honorarium in exchange for donating a minimum of one piece to the NASA archive, which now numbers more than 800 works of art. In addition more than 2,000 works have been donated to the National Air and Space Museum.

In accordance with SFFAS No. 8, heritage assets that are used in day-to-day government operations are considered "multi-use" heritage assets that are not used for heritage purposes. Such assets are accounted for as general property, plant, and equipment and are capitalized and depreciated in the same manner as other general property, plant, and equipment. NASA has 84 buildings and structures considered to be "multi-use" heritage assets. The values of these assets are included in the property, plant, and equipment values shown in the financial statements.

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Year Ended September 30, 2004
(In Thousands of Dollars)

Research and Development Expenses by Enterprise by Programs/Applications

In August 2004, NASA restructured from six Strategic Enterprises—Human Exploration and Development of Space, Space Science, Earth Science, Biological and Physical Research, Aerospace Technology, and Education Programs—to four Mission Directorates: Exploration Systems, Space Operations, Science, and Aeronautics Research.

This schedule could not be provided due to the organizational transformation that occurred in August 2004 of six Strategic Enterprises to four Mission Directorates. The detailed breakdown of the appropriations by research and development was not available due to the late year transformation.

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Years Ended September 30
(In Thousands of Dollars)

Research and Development Expenses by Enterprise by Programs/Applications

	2003	2002	2001 (Restated)	2000	1999
Human Exploration and Development of Space					
Space Station (a)					
Basic Research	$ —	$ —	$ —	$ —	$ —
Applied Research	—	—	—	—	99,678
Development	—	—	—	—	2,456,172
Subtotal	$ —	$ —	$ —	$ —	$ 2,555,850
Space Operations					
Basic Research	$ 69,342	$ 369,737	$ 147,869	$ 457,582	$ —
Applied Research	—	—	92,419	—	—
Development	—	—	129,386	—	430,503
Subtotal	$ 69,342	$ 369,737	$ 369,674	$ 457,582	$ 430,503
Investment and Support (b)					
Basic Research	$ —	$ —	$ —	$ —	$ —
Applied Research	—	27,453	164,241	—	—
Development	—	—	—	—	—
Subtotal	$ —	$ 27,453	$164,241	$ —	$ —
Payload Utilization and Operations					
Basic Research	$ —	$ —	$ —	$ —	$ —
Applied Research	217,999	180,888	153,324	419,452	375,970
Development	—	—	—	—	—
Subtotal	$ 217,999	$180,888	$ 153,324	$ 419,452	$ 375,970
HEDS Total	**$ 287,341**	**$578,078**	**$ 687,239**	**$ 877,034**	**$ 3,362,323**
Space Science (SSE)					
Space Science					
Basic Research	$ 995,286	$988,677	$ 581,163	$ 818,718	747,763
Applied Research	—	—	—	—	816,433
Development	1,761,738	1,836,115	1,179,937	1,625,216	979,212
Subtotal	$ 2,757,024	$2,824,792	$ 1,761,100	$ 2,443,934	$ 2,543,408
Planetary Exploration					
Basic Research	$ —	$ —	$ —	$11,152	$ 10,049
Applied Research	—	—	—	—	10,972
Development	—	—	—	22,137	13,160
Subtotal	$ —	$ —	$ —	$33,289	$ 34,181
SSE Total	**$ 2,757,024**	**$ 2,824,792**	**$ 1,761,100**	**$ 2,477,223**	**$ 2,577,589**
Earth Science (ESE)					
Basic Research	$ 629,343	$ 544,676	$ 255,678	$494,956	$ 358,782
Applied Research	71,055	105,661	55,161	97,018	130,625
Development	568,439	837,850	434,577	1,052,397	1,252,260
ESE Total	**$ 1,268,837**	**$ 1,488,187**	**$ 745,416**	**$ 1,644,371**	**$ 1,741,667**
Biological and Physical Research (BPR) (c)					
Basic Research	$ 396,351	$ 209,573	$ 69,603	$ 107,951	$ 162,858
Applied Research	804,673	415,546	112,221	166,746	119,548
Development	129,013	95,064	32,338	46,586	14,239
BPR Total	**$ 1,330,037**	**$ 720,183**	**$ 214,162**	**$ 321,283**	**$ 296,645**

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Years Ended September 30 (Continued)
(In Thousands of Dollars)

Research and Development Expenses by Enterprise by Programs/Applications (Continued)

	2003	2002	2001 (Restated)	2000	1999
Aerospace Technology (AT)					
Aerospace Technology					
Basic Research	$ —	$ —	$ —	$ 144,053	$ 356,546
Applied Research	1,083,956	2,398,468	1,039,635	906,288	910,027
Development	—	—	—	83,937	20,595
Subtotal	$ 1,083,956	$ 2,398,468	$ 1,039,635	$ 1,134,278	$ 1,287,168
Advanced Space Transportation					
Basic Research	—	—	—	—	—
Applied Research	5,533	16,049	83,971	512,409	569,775
Development	—	—	—	—	—
Subtotal	$ 5,533	$ 16,049	$ 83,971	$ 512,409	$ 569,775
Commercial Technology					
Basic Research	3,776	—	—	—	99,080
Applied Research	104,105	342,302	127,697	171,591	45,341
Development	—	12,415	—	6,224	23,510
Subtotal	$ 107,881	$ 354,717	$ 127,697	$ 177,815	$ 167,931
AT Total	**$ 1,197,370**	**$ 2,769,234**	**$ 1,251,303**	**$ 1,824,502**	**$ 2,024,874**
Education (formerly Academic Programs)					
Basic Research	121,649	81,271	97,112	71,504	93,339
Applied Research	47,307	33,844	42,017	39,873	19,657
Development	—	—	—	—	13,823
Education Total	**$ 168,956**	**$ 115,115**	**$ 139,129**	**$ 111,377**	**$ 126,819**
Total Research and Development Expenses by Program	**$ 7,009,565**	**$ 8,495,589**	**$ 4,798,349**	**$ 7,255,790**	**$ 10,129,917**

Non-Research and Development Expenses by Enterprise by Programs/Applications

	2003	2002	2001 (Restated)	2000	1999
Human Exploration and Development of Space (HEDS)					
Space Shuttle	$ 3,008,610	$ 3,232,011	$ 2,100,835	$ 3,303,230	$ 3,285,407
Space Station	1,510,049	1,727,749	(1,253,026)	2,754,089	—
Investment and Support	145,031	438,428	—	—	—
Space Communication and Data Services	295,008	(18,363)	25,776	—	184,978
Safety, Reliability, and Quality Assurance	—	69,868	40,037	—	—
Mission Communication Services	(46,608)	253,654	32,199	—	—
U.S. Russian Cooperative	52	(2)	208	22,124	151,396
HEDS Total	**$ 4,912,142**	**$ 5,703,345**	**$ 946,029**	**$ 6,079,443**	**$ 3,621,781**
Space Science (SSE)					
Planetary Exploration	—	(232)	787	—	—
SSE Total	**$ —**	**$ (232)**	**$ 787**	**$ —**	**$ —**
Other Programs	**$ 53,940**	**$ 138,969**	**$ 131,737**	**$ 1,271**	**$ 832**
Reimbursable Expenses	**-**	**-**	**-**	**$ 737,498**	**$ 817,810**
Total Non-Research and Development Expenses by Program	**$ 4,966,082**	**$ 5,842,082**	**$ 1,078,553**	**$ 6,818,212**	**$ 4,440,423**
Total Program Expenses	**$ 11,975,647**	**$ 14,337,671**	**$ 5,876,902**	**$ 14,074,002**	**$ 14,570,340**

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Years Ended September 30 (Continued)

NASA makes substantial research and development investments for the benefit of the United States. These amounts are expensed as incurred in determining the net cost of operations.

NASA's research and development programs include activities to extend our knowledge of Earth, its space environment, and the universe, and to invest in new aeronautics and advanced space transportation technologies that support the development and application of technologies critical to the economic, scientific, and technical competitiveness of the United States.

Investment in research and development refers to those expenses incurred to support the search for new or refined knowledge and ideas and for the application or use of such knowledge and ideas to develop new or improved products and processes with the expectation of maintaining or increasing national economic productive capacity or yielding other future benefits. Research and development is composed of:

- **Basic research:** Systematic study to gain knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind;

- **Applied research:** Systematic study to gain knowledge or understanding necessary for determining the means by which a recognized and specific need may be met; and

- **Development:** Systematic use of the knowledge and understanding gained from research for the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

The strategies and resources that NASA uses to achieve its performance goals are highlighted in Part I: Management Discussion and Analysis of this report. It also provides information regarding the relationship between performance outcomes and outputs to the stewardship investments outlined above. See the FY 2004 Performance Highlights section of Part I for further details.

(a) OMB revised its rules in FY 2000, and no longer considered International Space Station as Investment in Research and Development, as in previous years. Therefore, in FY 2000, Space Station became part of Non-Research and Development Expenses by Program.

(b) In FY 2002, NASA's appropriation structure was realigned to incorporate the functions of the former Mission Support appropriation to Science, Aeronautics and Technology and the Human Space Flight. This realignment changed the functionality from a Research and Development program to both Research and Development and Non-Research and Development, as indicated on the schedule above.

(c) In FY 2001, NASA established a new Enterprise, Biological and Physical Research. This initiative transferred Life and Microgravity Science and Applications activities to Biological and Physical Research.

Enterprise/Program/Application Descriptions

- The **Human Exploration and Development of Space** seeks to expand the frontiers of space and knowledge by exploring, using, and enabling the development of space.

- The **Space Station**, referred to as the International Space Station, is a research facility in low Earth orbit in which U.S., Russian, Canadian, European, and Japanese astronauts are conducting unique scientific and technological investigations in a microgravity environment.

- **Space Operation**'s goal is to provide highly reliable and cost-effective space operations services in support of NASA's science and aeronautics programs.

- The **Investment and Support** Rocket Propulsion Test Support activity will continue to ensure NASA's rocket propulsion test capabilities are properly managed and maintained in world class condition.

- The **Payload Utilization and Operations** program is the "one-stop shopping provider" for all customer carrier needs and requirements for safe and cost effective access to space via the Space Shuttle.

National Aeronautics and Space Administration
Required Supplementary Stewardship Information
Stewardship Investments: Research and Development
For the Fiscal Years Ended September 30 (Continued)

Enterprise/Program/ Application Descriptions (Continued)

- **Space Science** seeks to understand the evolution and destiny of the universe and its galaxies, stars, and planetary bodies, and the potential for life in the solar system and beyond.

- The **Planetary Exploration** program encompasses the scientific exploration of the solar system, including the planets and their satellites, comets, and asteroids.

- **Earth Science** develops a scientific understanding of the Earth system and its response to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations.

- **Biological and Physical Research** affirms NASA's commitment to the essential role biology will play in the 21st century, and supports the high-priority biological and physical sciences research needed to achieve Agency strategic objectives.

- **Aerospace Technology** works to advance U.S. preeminence in aerospace research and technology. The Enterprise aims to greatly improve air travel, making it safer, faster, and quieter as well as more affordable, accessible, and environmentally sound.

- **Advanced Space Transportation** will create a safe, affordable highway through the air and into space by improving safety, reliability, and operability, while significantly reducing the cost of space transportation systems.

- NASA's **Commercial Technology Program** facilitates the transfer to the private sector NASA inventions, innovations, discoveries, or improvements developed by NASA personnel or in partnership with industry and universities.

- **Education (formerly Academic Programs)** consists of two components, the Educational Program and the Minority University Program. Together, these two components of the Academic Programs effort provide guidance for the Agency's interaction with the formal and informal education community.

- The **Space Shuttle** is a partially reusable space vehicle that provides several unique capabilities to the United States space program. These include retrieving payloads from orbit for reuse; servicing and repairing satellites in space; safely transporting humans to and from space; launching Station components and providing an assembly platform in space; delivering facilities to the Station; and providing stowage and support services for research payloads traveling to and from the Station.

- **Space Communications and Data Services** supports NASA's Enterprises and external customers with communication and data relay and tracking services that are responsive to customer needs.

- The **Safety, Reliability, and Quality Assurance** program invests in the safety and success of NASA missions by assuring that sound and robust policies, processes, and tools for safety, reliability, quality assurance, and engineering disciplines are in place and applied throughout NASA.

- The **Mission Communication Services** program, one part of NASA's Space Communications program, provides support to the breadth of NASA missions, including planetary and interplanetary missions; human space flight missions; Earth-orbiting and spacecraft missions; suborbital missions; and aeronautical test flight systems.

- The **U.S./Russian Cooperative** program includes all flight activities in support of the joint space missions involving the Space Shuttle and the Russian *Mir* Space Station.

- **Other Programs** includes the mission of the Office of Inspector General and programs not directly supportive of a single Enterprise.

National Aeronautics and Space Administration
Required Supplementary Information

Combined Schedule of Budgetary Resources
For the Year Ended September 30, 2004
(In Thousands of Dollars)

Current year activity (opening balances) is required to prepare the required supplemental information for the combined statement of budgetary resources. This information was not available, as discussed in Note 16.

National Aeronautics and Space Administration
Required Supplementary Information
Combined Schedule of Budgetary Resources
For the Year Ended September 30, 2003
(In Thousands of Dollars)

	Science, Aeronautics, and Technology	Human Space Flight	Mission Support	Other	Total
Budget Authority					
Appropriation	$ 9,207,665	$ 6,230,900	$ —	$ 12,789	$ 15,451,354
Net Transfers (+ or -)	66,927	(67,052)	—	—	(125)
Unobligated Balance					
Brought Forward, October 1 (+ or -)	659,339	377,404	72,421	18,756	1,127,920
Spending Authority from Offsetting Collections					
Earned					
Collected	461,595	251,582	6,854	—	720,031
Receivable from Federal Sources	9,868	(4,746)	(2,505)	—	2,617
Change in Unfilled Orders					
Advance Received	(44,539)	16,445	(4,073)	—	(32,167)
Without Advance	(30,496)	(39,173)	5,466	—	(64,203)
Recoveries of Prior Year Obligations—Actual	102,953	12,613	65,940	24	181,530
Permanently Not Available					
Cancellations of Expired/No-Year Accounts	(30,734)	(3,672)	(10,784)	(543)	(45,733)
Pursuant to Public Law	(59,850)	(15,242)	—	(166)	(75,258)
Total Budgetary Resources	**$ 10,342,728**	**$ 6,759,059**	**$ 133,319**	**$ 30,860**	**$ 17,265,966**
Obligations Incurred					
Direct					
Category A	$ —	$ —	$ —	$ 1,000	$ 1,000
Category B	8,734,422	6,002,344	98,242	23,441	14,858,449
Reimbursable					
Category B	528,963	249,366	(412)	380	778,297
Unobligated Balance					
Balance Currently Available	1,039,535	496,006	14,429	723	1,550,693
Trust Funds	—	—	—	3,616	3,616
Not Available, Other	39,808	11,343	21,060	1,700	73,911
Total Status of Budgetary Resources	**$ 10,342,728**	**$ 6,759,059**	**$ 133,319**	**$ 30,860**	**$ 17,265,966**
Obligated Balance, Net as of October 1	$ 3,747,214	$ 1,696,630	$ 186,863	$ 2,700	$ 5,633,407
Obligated Balance, Net End of Period					
Accounts Receivable	(43,030)	(17,654)	(416)	—	(61,100)
Unfilled Customer Orders from Federal Sources	(6,627)	15,728	479	—	9,580
Undelivered Orders	2,680,715	879,291	47,133	1,651	3,608,790
Accounts Payable	1,522,115	800,315	30,752	1,091	2,354,273
Outlays					
Disbursements	8,775,101	6,301,967	137,842	24,755	15,239,665
Collections	(417,056)	(268,028)	(2,780)	—	(687,864)
Less: Offsetting Receipts	—	—	—	6	6
Net Outlays	**$ 8,358,045**	**$ 6,033,939**	**$ 135,062**	**$ 24,749**	**$ 14,551,795**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
For the Year Ended September 30, 2004
(In Thousands of Dollars)

Intragovernmental Assets

Agency	Fund Balance with Treasury	Investments	Accounts Receivable	Advances and Prepaid Expenses
Treasury	$ 7,629,298	$ 17,077	$ 69	$ —
Air Force	—	—	53,431	—
Army	—	—	9,046	—
Commerce	—	—	25,569	—
Navy	—	—	9,868	—
National Science Foundation	—	—	177	—
Secretary of Defense	—	—	5,521	—
Transportation	—	—	5,264	—
Other	—	—	7,420	—
Total	**$ 7,629,298**	**$ 17,077**	**$ 116,365**	**$ —**

Intragovernmental Liabilities

Agency	Accounts Payable	Closed Accounts Payable	Workers' Compensation	Liability for Deposit and Clearing Funds
Air Force	$ 23,117	$ 75	$ —	$ —
Army	489	(477)	—	—
Commerce	258	242	—	—
Energy	13,550	(12)	—	—
Labor	32	—	15,787	—
Navy	3,876	(1)	—	—
Interior	—	—	—	—
National Science Foundation	2,488	—	—	—
Secretary of Defense	6,571	10	—	—
Treasury	525	—	—	—
Transportation	(1,111)	—	—	—
Other	20,188	4,152	—	781
Total	**$ 69,983**	**$ 3,989**	**$ 15,787**	**$ 781**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
For the Year Ended September 30, 2004 (Continued)
(In Thousands of Dollars)

Intragovernmental Liabilities (Continued)

Agency	Advances from Others	Other Liabilities	Employer Contributions and Payroll Taxes	Custodial Liability
Air Force	$ 45,703	$ —	$ —	$ —
Army	17,004	—	—	—
Commerce	8,246	—	—	—
Energy	192	—	—	—
Office of Personnel Management	—	—	440	—
Interior	—	—	—	—
National Science Foundation	3	—	—	—
Navy	1,563	—	—	—
Secretary of Defense	6,178	—	—	—
Transportation	5,021	—	—	—
Treasury	9	—	—	—
Veteran's Affairs	4,737	—	—	—
Other	1,912	1,214	—	2,082
Total	**$ 90,568**	**$ 1,214**	**$ 440**	**$ 2,082**

Agency	Intragovernmental Revenue	Intragovernmental Expense
Air Force	$ 248,641	$ 133,668
Army	45,515	41,111
Commerce	209,911	16,540
Energy	2,415	125,409
Environmental Protection Agency	1,552	262
National Science Foundation	1,031	12,515
Navy	51,570	35,633
Secretary of Defense	45,304	88,567
Transportation	17,874	17,649
Treasury	221	2,765
Interior	2,906	21,329
Agriculture	4,879	3,756
Veteran's Affairs	932	282
Other	(15,766)	556,989
Total	**$ 616,985**	**$ 1,056,475**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
For the Year Ended September 30, 2003
(In Thousands of Dollars)

Intragovernmental Assets

Agency	Fund Balance with Treasury	Investments	Accounts Receivable	Advances and Prepaid Expenses
Treasury	$ 7,492,506	$ 17,138	$ 62	$ —
Air Force	—	—	21,890	—
Army	—	—	5,423	—
Commerce	—	—	14,380	2,581
Navy	—	—	4,203	4,438
National Science Foundation	—	—	37	380
Secretary of Defense	—	—	9,732	—
Transportation	—	—	1,693	—
Other	—	—	3,724	—
Total	**$ 7,492,506**	**$ 17,138**	**$ 61,144**	**$ 7,399**

Intragovernmental Liabilities:

Agency	Accounts Payable	Closed Accounts Payable	Workers' Compensation	Liability for Deposit and Clearing Funds
Air Force	$ 17,187	$ —	$ —	$ —
Army	872	—	—	—
Commerce	12,630	—	—	—
Energy	9,402	—	—	—
Labor	—	—	15,324	—
Navy	292	—	—	—
Interior	9,872	—	—	—
National Science Foundation	2,723	—	—	—
Secretary of Defense	18,979	—	—	—
Treasury	91	—	—	—
Transportation	4,605	—	—	—
Other	20,278	32	—	6
Total	**$ 96,931**	**$ 32**	**$ 15,324**	**$ 6**

National Aeronautics and Space Administration
Required Supplementary Information
Intragovernmental Transactions
For the Year Ended September 30, 2003 (Continued)
(In Thousands of Dollars)

Agency	Advances from Others	Lease Liabilities	Accrued Funded Payroll	Custodial Liability
Air Force	$ 8,253	$ —	$ —	$ —
Army	888	—	—	—
Commerce	5,029	—	—	—
Energy	660	—	—	—
Office of Personnel Management	—	—	6,362	
Interior	2,975	—	—	—
National Science Foundation	3,032	—	—	—
Navy	3,874	—	—	—
Secretary of Defense	13,140	—	—	—
Transportation	3,422	—	—	—
Treasury	45	—	—	—
Veteran's Affairs	4,334	—	—	—
Other	4,590	—	—	2,056
Total	**$ 50,242**	**$ —**	**$ 6,362**	**$ 2,056**

Agency	Intragovernmental Revenue
Air Force	$ 142,991
Army	19,497
Commerce	28,409
Energy	70,892
Environmental Protection Agency	1,332
National Science Foundation	17,246
Navy	6,480
Secretary of Defense	145,949
Transportation	23,789
Treasury	1,108
Interior	18,720
Agriculture	8,112
Veteran's Affairs	977
Other	172,058
Total	**$ 657,560**

National Aeronautics and Space Administration
Required Supplementary Information

Deferred Maintenance
For the Year Fiscal Ended September 30, 2004

NASA has deferred maintenance only on its facilities, including structures. There is no significant deferred maintenance on other physical property, such as land, equipment, Theme assets, leasehold improvements, or assets under capital lease. Contractor-held property is subject to the same considerations.

NASA developed a Deferred Maintenance parametric estimating method (DM method) in order to conduct a consistent condition assessment of its facilities. This method was developed to measure NASA's current real property asset condition and to document real property deterioration. The DM method produces both a parametric cost estimate of deferred maintenance, and a Facility Condition Index. Both measures are indicators of the overall condition of NASA's facility assets. The DM method is designed for application to a large population of facilities; results are not necessarily applicable for individual facilities or small populations of facilities. Under this methodology, NASA defines acceptable operating condition in accordance with standard comparable to those used in private industry, including the aerospace operating condition in accordance with standards comparable to those used in private industry, including the aerospace industry.

While there have been no significant changes in our deferred maintenance parametric estimating method this year, there have been several administrative changes, including reclassifying building real property to personal property, and better estimates of current value, had a significant impact on the FY 2004 deferred maintenance and facility condition assessment. Using the DM method, NASA has an Agency-wide Facility Condition Index (FCI) for FY 2004 of 3.7 on a scale of 1 to 5, and NASA's estimate of its backing of maintenance and repair is approximately $1.67 billion for both active and inactive facilities. The NASA target Agency-wide average FCI is 4.3.

Deferred maintenance related to heritage assets is included in the deferred maintenance for general facilities. Maintenance is not deferred on active assets that require immediate repair to restore them to safe working condition and have an Office of Safety and Mission Assurance Risk Assessment Classification Code 1 (see NASA STD 8719.7).

National Aeronautics and
Space Administration

Office of Inspector General
Washington, DC 20546-0001

NOV 15 2004

TO: Administrator
Chief Financial Officer

SUBJECT: Audit of the National Aeronautics and Space Administration's Fiscal Year 2004 Financial Statements

Under the Chief Financial Officers Act of 1990, NASA's financial statements are to be audited in accordance with generally accepted government auditing standards. The Office of Inspector General selected the independent certified public accounting firm Ernst & Young LLP (E&Y) to audit NASA's financial statements in accordance with *Government Auditing Standards* and Office of Management and Budget's (OMB) Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements.*

In the enclosed *Report of Independent Auditors,* E&Y disclaimed an opinion on NASA's financial statements for the fiscal year ended September 30, 2004. The disclaimer resulted from NASA's inability to provide E&Y auditable financial statements and sufficient evidence to support the financial statements throughout the fiscal year and at year-end.

The E&Y *Report on Internal Control* includes five reportable conditions of which four are considered to be material weaknesses. Material weaknesses were found in NASA's controls for: (1) financial systems, analyses and oversight used to prepare the financial statements, (2) reconciling differences in the Fund Balance with Treasury, (3) assuring that property, plant, and equipment and materials are presented fairly in the financial statements, and (4) securing the computing environment that supports the Integrated Financial Management Program. The final reportable condition concerns weaknesses in NASA's controls for estimating environmental liability.

The E&Y *Report on Compliance with Laws and Regulations* identifies several instances in which NASA's financial management systems did not substantially comply with *Federal Financial Management Improvement Act (FFMIA)* requirements. For example, the report notes that certain subsidiary systems, including property, are not integrated with the Core Financial Module. The report also questions whether the Agency fully complied with the *Improper Payment Information Act of 2002* because NASA's risk assessment focused on payments related only to firm-fixed price contracts and because the Agency did not prepare an estimate of improper payments.

Many of the issues identified by E&Y are attributable to implementation problems and weaknesses in the Core Financial Module, which is the backbone of the Agency's

Integrated Financial Management Program. We believe that a lack of consistency in the way financial data was processed in the less disciplined legacy environment contributed to the data conversion and integrity problems the Agency is now facing. While the Agency faces a formidable challenge completing implementation of the Integrated Financial Management Program, we believe the decision to implement a single integrated Agency-wide system was correct. Had the Agency not elected to implement an integrated financial system, we sincerely doubt that even heroic efforts by NASA and its auditor using the legacy systems would have resulted in reliable financial reporting within the accelerated time frames now required of Executive Branch agencies. Replacing the disparate legacy accounting systems at the nine NASA Centers and Headquarters with an integrated financial system represents a critical step to improving the Agency's financial management.

To address the weaknesses that E&Y reported, NASA should finalize and implement its Financial Management Improvement Plan with particular emphasis on:

- Ensuring that the Chief Financial Officer's Office is staffed to address the Agency's financial management and accountability challenges.

- Ensuring that accounting policies and procedures are consistent with applicable standards and are consistently applied.

- Establishing internal controls that provide reasonable assurance that the financial statements are supported, complete and accurate.

- Identifying and correcting data conversion and integrity problems in the Core Financial Module.

- Implementing recommendations made in E&Y's *Report on Internal Control*, and those made by our office and the Government Accountability Office.

E&Y is responsible for each of the enclosed reports and the conclusions expressed within. Accordingly, we do not express an opinion on NASA's financial statements, internal controls over financial reporting, or compliance with certain laws and regulations including, but not limited to, FFMIA.

In fulfilling our responsibilities under the Chief Financial Officers Act of 1990, we provided oversight and technical support. We monitored the progress of the audit, reviewed reports submitted by E&Y, and ensured that they met contractual requirements.

Robert W Cobb

Robert W. Cobb

3 Enclosures

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Report of Independent Auditors

To the Administrator and the Office of Inspector General of the National Aeronautics and Space Administration:

We were engaged to audit the accompanying consolidated balance sheet of the National Aeronautics and Space Administration (NASA) as of September 30, 2004, and the related consolidated statement of net costs, statements of changes in net position and financing, and combined statement of budgetary resources for the fiscal year then ended. These financial statements are the responsibility of NASA's management. The financial statements as of September 30, 2003, and for the fiscal year then ended, were reported on by other auditors whose report dated January 20, 2004 disclaimed an opinion on those statements and described certain departures from generally accepted accounting principles regarding disclosures related to significant differences between its Fund Balance with Treasury balance per its general ledger and Treasury's reported balance, consistency of presentation of the statement of financing, and certain matters relating to a change in fiscal year 2003 in NASA's approach in allocating depreciation expenses and capitalized costs.

During fiscal year 2003, NASA implemented an Integrated Financial Management Program (IFMP) system, specifically the Core Financial Module. NASA's management identified significant errors beginning with its September 30, 2003 financial statements resulting from the implementation of the IFMP system. During fiscal year 2004, NASA's management continued to identify and resolve significant system conversion and data integrity issues, implement internal control and develop policies and procedures—much of which took place in the last quarter of fiscal year 2004. Additionally, management indicated that the Core Financial Module could not link manual adjustments/corrections to the original transaction. Further, NASA was unable to provide a subsidiary listing of outstanding balances to support certain financial statement balances including accounts payable and undelivered orders, and management was unable to represent that its financial statements were fairly stated. As a result of these limitations, we were unable to obtain sufficient evidential support for the amounts presented in the consolidated balance sheet as of September 30, 2004, and the related consolidated statement of net costs, statements of changes in net position and financing, and combined statement of budgetary resources for the fiscal year then ended.

Because of the matters discussed in the preceding paragraph, the scope of our work was not sufficient to enable us to express, and we do not express, an opinion on the consolidated balance sheet as of September 30, 2004, and the related consolidated statement of net costs, statements of changes in net position and financing, and combined statement of budgetary resources for the fiscal year then ended.

Report of Independent Auditors
Page 2 of 2

In its preparation and analysis of its September 30, 2004 financial statements, NASA's management identified certain configuration and data integrity issues and significant errors in balances reported on its financial statements. The footnotes to the financial statements describe certain departures from accounting principles generally accepted in the United States of America in NASA's fiscal year 2004 financial statements.

The information presented in the Management's Discussion and Analysis (MD&A), Required Supplementary Stewardship Information, and the Required Supplementary Information is not a required part of the NASA's financial statements, but is considered supplementary information required by Office of Management and Budget (OMB) Bulletin 01-09, *Form and Content of Agency Financial Statements*. Such information has not been subjected to auditing procedures, and accordingly, we express no opinion on it. We were unable to apply to the information certain procedures prescribed by professional standards within the timeframes established by OMB, because of the limitations on the scope of our audit of the financial statements, discussed above. Additionally, we were unable to assess control risk relevant to NASA's intra-governmental transactions and balances, as required by OMB Bulletin 01-02, *Audit Requirements for Federal Financial Statements*, because reconciliations were not performed with certain Federal trading partners as required by OMB Bulletin 01-09. Finally, as discussed in Footnote One, programs identified in the financial statements do not directly align with the major goals and outputs described in the MD&A.

In accordance with *Government Auditing Standards*, we have also issued our reports dated October 29, 2004, on our consideration of NASA's internal control over financial reporting and on our tests of its compliance with certain provisions of laws, regulations, and other matters. The purpose of those reports is to describe the scope of our testing of internal controls over financial reporting and compliance and the results of that testing, and not to provide an opinion on the internal control over financial reporting or on compliance. Those reports are an integral part of an audit performed in accordance with *Government Auditing Standards* and should be considered in assessing the results of our work.

Ernst + Young LLP

Washington, D.C.
October 29, 2004

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Report on Internal Control

To the Administrator and the Office of Inspector General
of the National Aeronautics and Space Administration:

We were engaged to audit the financial statements of the National Aeronautics and Space Administration (NASA) as of and for the year ended September 30, 2004, and have issued our report thereon dated October 29, 2004. The report states that because of the matters discussed therein, the scope of our work was not sufficient to enable us to express, and we do not express, an opinion on the consolidated balance sheet as of September 30, 2004, and the related consolidated statement of net costs, statements of changes in net position and financing, and combined statement of budgetary resources for the fiscal year then ended.

In planning and performing our work, we considered NASA's internal control over financial reporting by obtaining an understanding of NASA's internal control, determined whether internal controls had been placed in operation, assessed control risk, and performed tests of controls. We limited our internal control testing to those controls necessary to achieve the objectives described in Office of Management and Budget (OMB) Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements*. We did not test all internal controls relevant to operating objectives as broadly defined by the Federal Managers' Financial Integrity Act (FMFIA) of 1982, such as those controls relevant to ensuring efficient operations. The objective of our work was not to provide assurance on internal control. Consequently, we do not provide an opinion on internal control.

Our consideration of the internal control over financial reporting would not necessarily disclose all matters in the internal control over financial reporting that might be reportable conditions. Under standards issued by the American Institute of Certified Public Accountants (AICPA), reportable conditions are matters coming to our attention relating to significant deficiencies in the design or operation of the internal control that, in our judgment, could adversely affect the agency's ability to record, process, summarize, and report financial data consistent with the assertions by management in the financial statements. Material weaknesses are reportable conditions in which the design or operation of one or more of the internal control components does not reduce to a relatively low level the risk that misstatements in amounts that would be material in relation to the financial statements being audited may occur and not be detected within a timely period by employees in the normal course of performing their assigned functions. Because of inherent limitations in internal controls, misstatements, losses, or noncompliance may nevertheless occur and not be detected. We noted certain matters discussed in the following paragraphs involving the internal control and its operation that we consider to be reportable conditions. We consider the first four matters noted—Financial Systems, Analyses and Oversight; Fund Balance with Treasury; Property; and Integrated Financial Management Program (IFMP) Systems Control Environment—to be material weaknesses.

MATERIAL WEAKNESSES

Financial Systems, Analyses and Oversight (Modified Repeat Condition)

Overview

OMB Circular A-127 requires that financial statements be the culmination of a systematic accounting process. The statements are to result from an accounting system that is an integral part of a total financial management system containing sufficient structure, effective internal control, and reliable data. As more fully described in NASA's draft Financial Management Improvement Plan, in Fiscal Year (FY) 2002, NASA initiated a seven-year Agency-wide effort to provide a single, integrated suite of financial, project, contract, and human capital tools to help manage NASA's programs and prepare financial information on a timely basis consistent with evolving OMB guidance. During FY 2003, NASA implemented an Integrated Financial Management Program (IFMP) system, specifically the Core Financial Module. The Core Financial Module replaced 10 disparate Center-level accounting systems and the NASA Headquarters accounting system, along with approximately 120 ancillary subsystems in operations for the past two decades. This conversion effort necessitated complex, extensive data cleanup, which was not always successfully completed.

NASA's management identified significant errors beginning with its September 30, 2003, financial statements resulting from the implementation of the IFMP system. During FY 2004, NASA's management continued to identify and resolve significant system conversion and data integrity issues, implement internal control, and develop policies and procedures. In its preparation and analysis of its September 30, 2004, financial statements, NASA's management continued to identify configuration and data integrity issues and significant errors in balances reported on its financial statements. Additionally, NASA's management indicated that the Core Financial Module could not provide an audit trail for certain transactions and was unable to provide subsidiary listings and certain supporting documentation.

NASA continues to work towards resolving issues noted in the FY 2003 financial statement audit report related to the lack of an integrated financial management system and inadequate financial accounting and supervisory review processes. Management reported certain actions, including:

- Financial Statement Preparation. Although management acknowledges weaknesses in the underlying data which preclude reliance on the statements at this time, IFMP has been configured to crosswalk standard general ledger accounts to the financial statements and selected notes to the financial statements, in accordance with OMB Bulletin No. 01-09, *Form and Content of Agency Financial Statements,* and the United States Standard General Ledger crosswalks prescribed by the Department of the Treasury (Treasury). Accordingly, the financial statements are produced directly from IFMP.

- Policies and Procedures. NASA published eight volumes of the new NASA Financial Management Requirements: Budget Execution, Accounting, Cost, External Reporting, Anti-Deficiency Act, Contract Financial Management, Grant Financial Management, and Working Capital Fund Policies and Requirements. Supplemental policy guidance was distributed for property, full cost implementation, and reimbursable agreements.

- Property. In addition to publishing definitive property, plant and equipment policy in the NASA Financial Management Requirements document in September 2004, major contracts were amended to require monthly reporting of property values. Process improvements in valuation practices and increased oversight by NASA and outside reviewers are included in ongoing efforts to improve reporting by contractors.

- Fund Balance with Treasury. NASA continues to make progress in resolving its Fund Balance with Treasury imbalance. While not completely reconciled, major differences identified in the FY 2003 financial statement audit have been researched and we were informed that many have been corrected. Corrective actions will continue into FY 2005.

- Organization Structure. NASA reorganized its operations so that certain procurement functions and the Chief Financial Officer (CFO) functions within the Centers report directly to NASA's CFO. Additionally, as part of the reorganization, NASA established a quality assurance office in the Office of the CFO to evaluate the efficacy of agency-wide management controls.

Although progress was made, significant financial management issues continue to impair NASA's ability to accumulate, analyze, and distribute reliable financial information. Our review of the internal control disclosed numerous weaknesses in NASA's ability to report accurate financial information on a timely basis. NASA's Core Financial System lacks integration with certain subsidiary systems, does not facilitate the preparation of the financial statements, and contains insufficient internal control to detect and support the correction of invalid entries in a timely fashion. Additionally, NASA personnel were not consistently utilizing uniform accounting processes that record, classify, and summarize information for the preparation of financial statements. Finally, NASA lacked formalized procedures to analyze accounting data, and sufficient source documentation to support reported financial information. Integrated financial systems, a sufficient number of properly trained personnel, and a strong oversight function are needed to ensure that periodic analyses and reconciliations are completed to detect and resolve errors and irregularities in a timely manner.

Lack of Integrated Financial Management System

The NASA financial management systems are not compliant with the Federal Financial Management Improvement Act of 1996 (FFMIA). FFMIA requires agencies to implement and maintain financial management systems that comply with Federal financial management systems requirements as defined by the Joint Financial Management Improvement Program (JFMIP). More specifically, FFMIA requires Federal agencies to have an integrated financial management system that provides effective and efficient interrelationships between software, hardware, personnel, procedures, controls, and data contained within the systems. The lack of an integrated financial management system continues to impair NASA and the Centers abilities to adequately support and analyze account balances reported.

Although NASA implemented a commercial off-the-shelf financial module approved by the JFMIP, certain aspects of the NASA accounting system lack integration and does not conform to the requirements currently specified by the JFMIP. As identified in Footnote Sixteen to the financial statements, NASA's management continues to identify data integrity and configuration issues in the Core Financial System which results in inappropriate transactional postings. Additionally, the Core Financial System is unable to provide detailed listings of balances to support NASA's September 30, 2004, reported balances. Finally, certain subsidiary systems, including property, are not integrated with the Core Financial System. Specific weaknesses noted include:

- During our audit work, we were unable to obtain a listing of balances from the Core Financial System. Specifically, we were unable to obtain a listing of balances to support accounts receivable, accounts payable, and undelivered orders to support financial statement amounts as of September 30, 2004. Additionally, NASA was unable to provide subsidiary listings of cash receipts and cash disbursements to support their budgetary outlays during the fiscal year. Currently, the Centers are able to provide certain subsidiary listings; however, the listings are being generated from ad-hoc processes, not directly from the Core Financial System.
- The Core Financial System does not provide for tracking manual of non-routine or correction entries with linkage back to the original transaction or the capability to isolate manual adjustments. As a result, adjustments and corrections cannot be readily identified.
- Certain subsidiary systems, including property, are not integrated with the Core Financial System. Entries for contractor-held property, totaling $8.5 billion, are recorded into the Core Financial System using manual vouchers.
- NASA's management continues to identify certain transactions that are being posted incorrectly due to improper configuration within the Core Financial System.
- Due to systematic limitations, NASA Centers are developing alternative approaches to ensure data and financial management information is readily available to make critical decisions. These alternatives are inconsistent between Centers and may cause varied results in reporting from the Centers to Headquarters.

Financial Statement Preparation and Analysis

During FY 2003, NASA implemented the Core Financial Module of the IFMP system. Because of the complexity of its conversion and the pervasiveness of errors identified in the Core Financial Module as of September 30, 2003, financial statements amounts reported were found to be unreliable and not complete. Specific issues identified related to data integrity issues, limitations requiring system configuration updates, lack of sufficient audit trails and documentation, incorrect transactions within the Core Financial Module, and insufficient analyses and weaknesses in internal control to identify material misstatements in a timely fashion.

For purposes of preparing interim financial statements during FY 2004, NASA made the decision to utilize estimates in preparing its financial reporting to OMB and Treasury because financial statements generated from the Core Financial System were deemed unreliable. The estimates were based on Treasury reports, FY 2003 balances, and/or budgetary or planned outcomes. Our review of the June 30, 2004 interim financial statements generated by the Core Financial System identified the following:

- A difference of $5.3 billion between the assets on the balance sheet generated from the Core Financial System and the sum of liabilities and net position.
- The net costs of operations on the consolidated statement of net costs did not agree to the net costs of operations located on the statement of financing—the difference totaling approximately $2 billion.
- Obligations incurred on the statement of budgetary resources did not agree to obligations incurred on the statement of financing—the difference totaling approximately $4 million.

The pervasiveness of these errors prevented us from performing significant substantive audit procedures on NASA's June 30, 2004, financial statements.

Although NASA generated its financial statements from the Core Financial System at September 30, 2004, NASA's management continued to identify similar issues during FY 2004. As discussed in Footnote Sixteen of the September 30, 2004, financial statements, NASA's management reported that the correction of prior year transactions during FY 2004 resulted in misstatements to many budgetary and proprietary nominal accounts because the Core Financial System could not distinguish between current year transactions and the corrections to prior year transactions without processing the corrections as prior period adjustments or reopening FY 2003 to process the corrections as current year activity. Additionally, the data integrity issues identified during FY 2003 continued to impair FY 2004 opening balances. Finally, NASA continued to identify functionality and configuration issues that impaired its ability to prepare accurate and complete financial statements. For example, in our review of the September 30, 2004, financial statements, we noted the following concerns:

- During our testing, we identified situations where costs are not recorded properly. NASA designed its new Core Financial Module to include a system edit, whereby, if costs (and the corresponding liabilities) are greater than the associated obligations, the difference would not be recorded in NASA's general ledger but rather maintained outside of the general ledger system. Instead, the differences were adjusted at the contract/project-level by posting a liability to match the excess costs. Statement of Federal Financial Accounting Standards (SFFAS) No. 1, *Accounting for Selected Assets and Liabilities*, SFFAS No. 4 *Managerial Cost Accounting Concepts & Standards*, and NASA's

Financial Management Regulations require costs to be accrued in the period in which they are incurred and any corresponding liability to be recorded as an account payable, regardless of the associated amounts obligated.

- The Core Financial System was unable to provide a breakdown of costs by the four mission directorates which NASA has identified as significant segments. This is not consistent with the requirements of SFFAS No. 4.
- We noted instances where the Core Financial System did not agree to the crosswalk provided that supports the financial statements. Management indicated that manual adjustments were required to ensure accuracy in the reported balances and consistency among statements. The majority of the adjustments related to the Statement of Budgetary Resources.

Additional Controls Need to be Strengthened

The U.S. Government Accountability Office's (GAO) Standards for Internal Control in the Federal Government states that internal control activities help ensure that management's directives are carried out. The control activities should be effective and efficient in accomplishing the organization's control objectives. Examples of control activities include: top level reviews, reviews by management at the functional or activity level, segregation of duties, proper execution of transactions and events, accurate and timely recording of transactions and events, and appropriate documentation of transactions and internal control.

Because significant weaknesses exist in the Core Financial System, management must compensate for the weaknesses by implementing and strengthening additional controls that will ensure errors and irregularities are detected in a timely manner. The weaknesses identified impact NASA's ability to report accurate financial information. During FY 2004, we found that certain processes were not adequately performed to ensure differences were properly identified, researched and resolved in a timely manner, and that account balances were complete and accurate. The following represents specific areas that need enhanced periodic reconciliation and analysis procedures:

- <u>Manual or Non-Routine Transactions.</u> The Core Financial System does not provide for tracking of non-routine or correction entries with linkage back to the original transaction. Non-routine transactions are high risk and should be closely monitored. We noted that there was no unique identifier in the system to easily access these transactions.
- <u>Certification of NASA Center Activity.</u> Although the majority of financial activity is processed in the Centers, the Center CFO offices are not required to (1) certify that financial transactions are complete, accurate, and have been properly recorded, and (2) perform high level analytical procedures to ensure balances are not materially misstated. Further, there is limited headquarters review of monthly financial reconciliation and analyses procedures.

- Policies and Procedures. Until September 2004, NASA did not have formalized policies and procedures for developing its financial statements, the financial reporting analyses functions, or certain transactional processes. As a result, certain inconsistencies between Centers and Headquarters personnel were identified in the processing of similar transactions. The GAO's Standards for Internal Control in the Federal Government requires that internal control and all transactions need to be clearly documented in properly maintained management directives, administrative policies, or operating manuals. Once formalized policies are completed, personnel should be properly trained to ensure policies are properly implemented and adhered to.

- Assessment of Improper Payments. During FY 2004, NASA has informed OMB of the status of its implementation of the Improper Payment Information Act of 2002 (IPIA). In its risk assessment, NASA identified and tested only those payments related to firm-fixed price contracts from each of the centers. Although the IPIA discusses consideration of other types of payments that should be considered, including Federal awards made by recipients and sub-recipients subject to the Single Audit Act Amendments of 1996 as well as Federal grants and sub-grants expended by for-profit and non-U.S. based entities not subject to that Act, NASA did not test these payments or document the rationale for not considering these payments as part of the risk assessment.

- Documentation. We noted that adequate documentation to support certain transactions was not readily available. Our testing of transactions identified several items where we did not receive sufficient information to determine if the transaction was valid. For example, NASA could not provide documentation to support whether a grant accrual was required to be reported as part of its financial statements as of September 30, 2004.

- Correction of Errors. NASA was unable to identify and resolve errors in postings to the subsidiary ledgers and the general ledger in a timely fashion. During our testing of Undelivered Orders, we noted three transactions totalling more than $560 million that management identified as improper transactions caused by configuration issues within the Core Financial System. Some transactions dated back as early as March 2004 but are not expected to be resolved until FY 2005. Management at the Center has requested assistance from Headquarters to resolve the issue.

- Supervision and Review. During our testing of one of the larger theme assets, we noted that NASA made a $191 million error in calculating depreciation. The error appears to be the result of an error in a formula on a spreadsheet that the reviewer did not identify.

The GAO's *Standards for Internal Control in the Federal Government* indicates that internal control monitoring should assess the quality of performance over time and ensure that findings of audits and other reviews are promptly resolved. Without appropriate monitoring and oversight of contractor operations, deficiencies in internal control may allow material misstatements to occur without being identified in a timely manner.

Given the severity of these issues, including system and process limitations and expertise needed in the new and future financial reporting requirements, it will take a sustained commitment and a qualified support team to resolve these issues in preparation for FY 2005 and future years.

Recommendation

We recommend that NASA continue to develop and refine its financial management systems and processes to improve its accounting, analysis, and oversight of financial management activity. Specifically, we recommend NASA:

- Continue to improve its financial reporting and internal quality review procedures to reasonably assure that information presented in the Performance and Accountability report are accurate and are consistent with the requirements of OMB Bulletin No. 01-09.
- Configure the Core Financial System to provide a breakdown of net costs consistent with programs identified in NASA's strategic plan and in the Management, Discussion, and Analysis section of the Financial Statements.
- To ensure accuracy and completeness of work performed, supervisory reviews should be guided by preparation of a comprehensive checklist. For example, the process of supervisory review at Headquarters and the Centers should be enhanced to identify errors in a more timely fashion. This should include enhancements to high-level analysis; the development of an archiving mechanism so that historical information is available for future trending; and enhancements to oversight procedures to monitor the implementation of control procedures to provide independent checks of validity, accuracy, and completeness of amounts reported to NASA.
- Continue to refine its procedures to provide a mechanism for NASA Headquarters to monitor Centers' activities and enforce compliance with NASA financial management procedures. We suggest that a systematic methodology be devised to ensure that accounting policies and procedures are in compliance with generally accepted accounting principles. While the IFMP provides Center and Headquarters personnel access to certain transactions and account balance information, we encourage management to also access related support from Centers, review subsidiary ledgers for reasonableness, and obtain reconciliations and account analyses for review to ensure their timely preparation and resolution.
- Complete and document analytical procedures to ensure that logical relationships exist between various financial statement amounts, and that the relationships between the different statements and line items within each statement are appropriate. Variances from expected results should be researched and resolved.
- Revise its NASA-wide detailed timeline with specific milestones to ensure ample time and resources are available to complete the following tasks associated with preparing the financial statements and other elements of the Performance and Accountability report: (1) data collection, (2) data validation, (3) data compilation, and (4) detailed quality review.
- Ensure that systems used to prepare the financial statements are complete and have been sufficiently tested prior to interim and year-end reporting dates. NASA should continue to validate its data within the Core Financial Module to resolve issues with data integrity

issues that date back to system conversion in 2003.

- Devise short-term and long-term resolutions to IFMP systematic and integration issues and the lack of internal controls surrounding costs in excess of obligations and downward adjustments.
- Formally document roles and responsibilities of its Headquarters, IFMP Competency Center, and Center financial management personnel to ensure appropriate accountability is achieved at each level. Additionally, we recognize that resource limitations may constrain NASA's ability to execute its mission. Management should continue to focus on filling key vacancies within the financial management organization.
- Provide additional training for financial personnel to ensure that they understand their role in processing transactions, performing account analyses and reconciliations, maintaining supporting documentation, and updating their knowledge of financial reporting requirements.

Further Research Required to Resolve Fund Balance with Treasury Differences (Modified Repeat Condition)

An agency's Fund Balance with Treasury represents monies an agency can spend for authorized transactions, which are based on budget spending authorizations and are made available through Treasury warrants. Amounts available are increased or decreased as monies are collected and disbursed. Although Treasury serves as the central processing facility for federal entities, Treasury does not maintain independent accounting records of each agency's Fund Balance with Treasury, but relies instead on monthly data reported by each agency for its record of agency collections, disbursements, and Fund Balance with Treasury.

Throughout FY 2003, NASA implemented, in phases, a commercial off-the-shelf, Agency-wide, integrated financial management system that replaced 10 separate accounting systems in operation at NASA Centers. This effort, which involved converting accounting data in the "legacy" accounting systems to a new accounting system, created complex accounting issues for FY 2003. Consequently, as noted in the FY 2003 audit report, NASA posted year-end adjustments outside its Core Financial System, which indicated that the difference between its Fund Balance with Treasury balance and Treasury's balance was significantly greater than had been presented in its year-end reconciliation. In addition, these adjustments did not provide sufficient documentary evidence to explain the linkage between the adjustments and the unreconciled differences identified on Headquarters' Fund Balance with Treasury reconciliations as of September 30, 2003.

As NASA indicated in its Management, Discussion and Analysis section of the Performance and Accountability report, we were informed that NASA has been able to resolve a substantial portion of the Fund Balance difference with Treasury. During FY 2004, the NASA Headquarters and its centers expended much effort analyzing the FY 2003 year-end adjustments to the Fund Balance with Treasury account and the impact to other related accounts. As a result, NASA classified the transactions into four major categories: document conversion, canceled appropriations, trust fund transfer, and other reconciling items. Year-end adjustments involved thousands of transactions that were not processed through the new financial system, not coded correctly, or were included erroneously in the new system during the conversion.

Although we were informed that many errors from FY 2003 were resolved, significant errors within the accounting system are still being identified. As of September 2004, NASA had not completely identified and resolved certain errors that still exist within the Core Financial system. For example, we identified an absolute value difference of $313 million between the Core Financial System and the Treasury balance. In addition, the total amount reported in NASA's Budget Clearing Account as of September 30, 2004 was $19 million. These amounts may include the data conversion adjustments identified during FY 2003, as well as additional differences that have occurred throughout FY 2004. These balances will require further research to determine the cause of the errors and resulting resolutions.

Treasury regulations require that each federal entity ensure that it reconciles on a monthly basis its financial records with Treasury's records and that it promptly resolves differences. If this reconciliation is not adequately performed, loss, fraud, and irregularities could occur and not be promptly detected, and/or financial reports that are inaccurate may be prepared and used in decision-making.

Recommendation

We recommend that NASA improve its current procedures to ensure that all reconciling items are thoroughly researched, timely resolved, and reviewed by appropriate Center and Headquarters CFO personnel. In addition, NASA should retain all reports and documentation used in performing its Fund Balance with Treasury reconciliations to ensure that detailed documented explanations and resolution actions are maintained for a sufficient audit trail.

Enhancements Needed For Controls Over Property, Plant and Equipment and Materials (Modified Repeat Condition)

Consistent with prior year audit reports, our review of property, plant, and equipment (PPE), totaling approximately $34.6 billion, identified serious weaknesses in internal control that if not corrected could prevent material misstatements from being detected in a timely manner. NASA's management acknowledged these weaknesses in its Management, Discussion and Analysis to its financial statements and its FY 2004 FFMIA Statement of Assurance.

During FY 2003, NASA's management created an overall Corrective Action Plan to remedy deficiencies identified within prior year audit reports. During FY 2004, progress was made in implementing aspects of the plan. For example, NASA:

- Established a quality assurance program, utilizing the Defense Contract Audit Agency's (DCAA) services to review policies and procedures as well as, test transactions of NASA's significant contractors,

- Developed new policies and procedures to be fully implemented during FY 2005,
- Amended certain major contracts to require monthly reporting of property values, and
- Provided training to its contractors on a variety of topics germane to the audit issues identified in prior year audit reports and its own analysis and observations of several contractor locations.

NASA's approach to recognizing and accounting for fixed assets is heavily dependent on activities at its contractors, and subsequent reviews to determine amounts which should be capitalized. Currently, NASA expenses all costs and then performs a review of the transactions to determine which costs should be capitalized. The subsequent review and dependence on contractor reporting increases the risk that costs will not be properly capitalized. Until NASA successfully implements a single integrated system for reporting property, and develops a methodology to identify costs that need to be capitalized as the transaction is processed, the Agency will continue to experience difficulties in recording these transactions. Additionally, further emphasis on processes at the contractor locations, the Centers and Headquarters is needed to ensure that amounts reported in its financial statements are reliable.

During our testing, we noted significant weaknesses in the property area. The weaknesses we noted during FY 2004, most of which are consistent with last year's audit report, relate primarily to insufficient internal controls surrounding contractor-held PPE, materials and NASA-held theme assets and NASA-held work in progress (WIP). For example:

- The FY 2003 audit report recommended that NASA require contractors to create plans to resolve their respective deficiencies and NASA establish internal controls and policies and procedures to ensure the plans are created and carried out. In FY 2004, NASA established a quality assurance program, using the DCAA's services to review policies and procedures as well as test transactions of NASA's significant contractors. One component of DCAA's work is to review previous year's findings, including contractors' progress with resolution of deficiencies. We reviewed the results of DCAA's reviews and found that for the majority of the contractors visited, there does appear to have been improvement in the contractor's attempts to address and correct deficiencies in FY 2004. We believe, however, that continuous monitoring will be required to ensure further improvement is noted.
- Consistent with the FY 2003 recommendations, NASA should ensure that all of its contractors have formal policies and procedures to detect and correct errors reported on the NASA Form (NF) 1018. Additionally, it was recommended that NASA require its contractors to review PPE and Materials reported by subcontractors on NF 1018 before submitting the information to NASA. Within its new quality assurance program, DCAA's review program requires a determination as to whether or not the contractors have formal policies and procedures to detect and correct errors; and whether or not the contractor is performing validation of its subcontractor data. As a result of applying their procedures to the March 31, 2004 quarterly report, DCAA identified an error of approximately $300 million in the computation of WIP. Since the error was not detected

by the contractor's review process nor was it detected by the validation procedures performed by the NASA property branch, policies and procedures may not have been fully implemented.

- In FY 2003 the prior year auditors recommended that NASA transition its Corrective Action Plan into an annual "Audit Plan" that establishes annual objectives pertinent to the Agency's specific PPE and materials internal control and financial statement reporting goals. In FY 2004, NASA developed a matrix which identifies the high, medium and low risk contractors. The matrix was populated with such elements as significant findings and internal control deficiencies and significant amounts of property holdings. High risk contractors are scheduled to be reviewed every year, while medium and low risk contractors will be reviewed on a rotating basis at regular intervals. Based on the results of the DCAA's procedures, the development of a matrix to identify high, medium and low risk contractors was a beneficial process. Given the fact that the DCAA procedures were performed for most contractors as of March 31, 2004, this control only applied to the first six months of the year. NASA needs to continue to further refine the process in order that DCAA perform the agreed-upon procedures for the high risk contractors as close to September 30 as possible. This would provide additional assurance that any possible large errors that had not been detected by controls at the contractor or through the validation procedures performed by NASA personnel would be identified in order that the corrections could be made in a timely manner for the preparation of the annual financial statements. Finally, it is suggested that NASA re-evaluate each contractor annually for purposes of classifying it as a high risk, medium risk or low risk contractor.

- The FY 2003 audit report recommends that the development and update of policies and procedures related to property occur and training be provided to the appropriate parties to ensure an understanding of current requirements. On September 30, 2004, NASA management completed its update to its policies and procedures manual; however, because it was not completed until year-end, any effects to accounting and reporting of property would not be observed until FY 2005. Because of the new training manual and the expected implementation of the Contractor Held Asset Tracking Software (CHATS) to facilitate its contractor reporting process in FY 2005, annual training of personnel will continue to be essential to update the NASA contractor representatives, NASA property accountants, and property administrators on property-related requirements.

- During FY 2003, it was recommended that NASA further modify the NF 1018 reporting process for the remaining contractors to report on a quarterly basis. The contractual requirement for monthly reporting by contractors with anticipated property balances in excess of $10 million in property should allow for more timely and accurate reporting by the contractors. In FY 2004, NASA developed and implemented an estimation methodology in regard to categories of contractor held property. This methodology was designed to estimate the change in contractor held property for the period from June 30, 2004 to September 30, 2004, and to be used as a method to record the balances as of September 30, 2004 for most of the contractor held property. The estimates were revised, as appropriate, based on additional feedback from certain of the large contractors. However, certain calculations in the estimation process were dependent upon information provided by the contractors for the nine-month period ended June 30, 2003 and the nine-month period ended June 30, 2004—neither period which had been validated under the new quality assurance process.

- For FY 2005, NASA should further evaluate the estimation process to determine if the contractor held property balances can be subjected to certain agreed-upon procedures to be performed by DCAA much later in the fiscal year. In addition, as a result of the monthly reporting by the large contractors and the new CHATS project, we also suggest that NASA further analyze whether the estimation process should be continued in future years or are there other options available to utilize current data from the contractors as a result of the monthly reporting by large contractors and any new information available as a result of the CHATS implementation.

- As originally recommended last year, NASA should continue to ensure compliance with its documentation requirements by monitoring its contractors through management reviews and inspection visits. Additionally, NASA should continue to require complete supporting documentation for all PPE and Materials transactions, specifically for asset transfers. Finally, NASA should create a reconciliation process to reconcile all of its asset transfers on a quarterly basis and include within that process formal confirmations between the issuing contractor and the receiving contractor.

  Beginning in FY 2004, as part of its new quality assurance program, an ongoing portion of DCAA's work is to validate that selected transfers are properly documented and recorded. One of the procedures that DCAA performs as a part of its engagement is to send a confirmation to the sending/receiving party with regard to the specific transfer in/transfer out transaction that is being tested to insure the proper recording of the transfer as well as to establish that both parties of the transaction have made the proper entry on a timely basis.

- In addition, a component of NASA Headquarter's validation process of contractors' quarterly property reports is to review the documentation of significant transfers and to ensure that the transfer is reconciled between the two contractors. However, as a result of the significant number of transfers between and among contractors, we recommend that NASA continue to explore the possibility of creating a process to reconcile all of its asset transfers on a monthly/quarterly basis with a formal confirmation process between the issuing contractor and the receiving contractor.

- The FY 2003 audit report recommended that NASA create formal policies and procedures to ensure all appropriate costs are capitalized as part of NASA theme assets (formerly NASA held assets in space) and NASA-held WIP accounts. In addition, it recommended the development of formal cost allocation policies for theme assets, including specificity of what costs are required to be capitalized and what costs should be expensed. Additionally, NASA management should enhance its theme assets policy to specifically include what costs should be capitalized/expensed, including a uniform list of cost identifiers (e.g., Unique Project Numbers [UPNs]) that support each of those assets to ensure its policy is consistently applied and that a sufficient audit trail exists documenting management's assertions surrounding the value of each asset.

In FY 2004, NASA undertook a project to review its policies (both accounting and procedural) with respect to theme assets (previously referred to as assets in space) to identify the specific costs that should be capitalized and those that should be expensed. This policy incorporated financial and engineering authoritative guidance, as well as NASA program/project management policy to ensure the consistent application and documentation. However, due to the uniqueness of these assets, management has deferred implementation of this policy until NASA has (1) coordinated this approach with other agencies with similar assets, and (2) presented the approach to the Federal Accounting Standards Advisory Board, in order to ensure all federal requirements are fully implemented.

Recommendation

We recommend that NASA continue to focus on resolving prior year issues and completing its implementation of suggested recommendations and corrective action plans. In addition, we recommend that NASA fundamentally revisit its approach to capitalizing property. We also recommend that all NASA obligation documents and expenditures be coded to identify whether they relate to a property acquisition. Outlays so calculated would create a control for comparison to recorded property transactions and subsidy ledgers, be they NASA activities or contractors.

Improvements in the IFMP Control Environment Are Needed (Modified Repeat Condition)

As discussed above, over the last several years NASA has been migrating its accounting and financial management systems to a new system and processing environment intended, upon full implementation, to provide a comprehensive entity wide resource planning (ERP-SAP within NASA) system. Our assessment of the IFMP computing environment that supports NASA's significant financial applications indicated that several improvements are needed to strengthen the design and operating effectiveness of the Agency's information security program.

Weaknesses were identified at NASA in three control areas:

- Access Controls
- Systems Software
- Segregation of Duties

Access controls. When properly implemented, access controls can help ensure that critical systems assets are physically safeguarded and that logical access to sensitive computer programs and data is granted to users only when authorized and appropriate. Access controls over computer operating systems and data communications software are also closely related. Weaknesses in such controls can compromise the integrity of sensitive Agency data and increase the risk that such data may be inappropriately used and/or disclosed.

Access control weaknesses continue to be identified and represent a significant risk to the IFMP program. Procedures were not consistently followed for monitoring unused IDs, locked IDs, or access re-certifications. User accounts were not deactivated after several consecutive failed login attempts and auditing was not set up to help investigate failed attempts. The use of the Password Wizard for generating initial passwords, the use of complex passwords, and the change of user passwords at regular intervals were not enforced on certain systems across the Agency. Users were also not prohibited from selecting previously used passwords. In addition, a significant number of users had access to sensitive SAP transaction codes and authorizations, files, and queries. Changes to SAP user security profiles that were made to allow temporary powerful access to the production environment were not appropriately documented.

During penetration vulnerability testing at the Marshall Space Flight Center, weaknesses were identified related to user account and password management, Internet security, and systems software configuration. These weaknesses were identified in peripheral infrastructure systems critical to SAP.

Systems software. Systems software represents computer programs designed to operate and control the processing activities of computer hardware and related equipment. Systems software helps coordinate the input, processing, output, and data storage associated with all of the applications that are processed on a specific system. Weaknesses in such controls can compromise the integrity of sensitive Agency data and increase the risk that such data may be inappropriately used and/or disclosed.

System software weaknesses continue to be identified and represent a significant risk to the IFMP program. Testing of changes to system software was not always documented. Unnecessary services were enabled and access to sensitive system software utilities and system and object privileges were not appropriately controlled. Operating systems were not always updated to incorporate the latest available system fixes and security upgrades. In addition, system files were not adequately protected by file permissions and the Agency was unable to provide evidence of audit log reviews.

Segregation of Duties. Segregation of duties controls provide policies, procedures, and an organizational structure to prevent one or more individuals from controlling key aspects of computer-related operations and thereby conducting unauthorized actions or gaining unauthorized access to assets or records. Segregation of duties weaknesses continues to be identified and represent a significant risk to the IFMP program. We were informed that in order to correct errors attributed by NASA to weaknesses within the SAP industry solution used by NASA, a significant number of SAP application support personnel were given access to the development and production environments. This access enabled these individuals to potentially make unauthorized changes to the production environment and potentially be involved in the direct processing of accounting transactions. Also, additional competency center staff were occasionally granted additional roles to make changes directly in the production environment. Although we were informed that the competency center monitors all changes made to production data through its change management system, there is a risk that changes could be made to production data that bypass these change management and monitoring controls.

The level of risk associated with the matters noted depends in part upon the extent to which compensating controls (such as reconciliations and robust reviews of output) are in place and operating effectively during the audit period. Certain of these controls designed to detect errors or inappropriate processing may also not be executed in a manner which can be expected to identify errors which, while perhaps not material to the financial statements as a whole, may subject NASA to the risks regarding safeguarding of assets. Within the context of the overall ineffective control environment referenced in the accompanying comments, the information technology related issues discussed above merit management focus.

Recommendation

NASA should implement controls to address deficiencies in access controls, systems software controls, and segregation of duties to include:

- Monitoring and reviewing the activities of users with powerful access privileges and eventually segregating such production access and ability to create accounting transactions from the development function.
- Consistently following procedures related to user account management.
- Implementing stronger password controls and restricting user access to programs and data to the minimum level required by the user's responsibilities.
- Disabling unnecessary system software services, restricting access to sensitive software utilities, and updating operating systems in a timely manner.

REPORTABLE CONDITION

Internal Controls in Estimating NASA's Environmental Liability Require Enhancement

During our review of NASA's environmental liability estimates totaling $986 million as of September 30, 2004, and related disclosures to the financial statements, we noted weaknesses in NASA's ability to generate an auditable estimate of its environmental unfunded liabilities and to identify disclosure items because of a lack of sufficient, auditable evidence. In general, we noted the following:

- NASA's Accounting, Environmental and Legal functions' roles and responsibilities for the estimation of the unfunded environmental liability are not sufficiently defined to ensure appropriate integration and input into the process. NASA's accounting function defers to the environmental practice in preparation of the estimates, resulting in environmental professionals interpreting accounting requirements.
- As of September 2004, NASA personnel and its contractors had not received sufficient policies, procedures and training in the process for estimating environmental liabilities. Although NASA released in June 2004 an environmental cost restoration handbook to

provide guidance to the NASA centers, the handbook was not adequately detailed to support a reliable estimate.

- NASA did not have adequate, auditable documentation to support its 2004 environmental liability estimates.
- NASA does not have documented quality control or quality assurance procedures to ensure the accuracy of the unfunded environmental liability estimates.

Roles and Responsibilities Need Further Refinement

During our testing of the unfunded environmental liability estimates, we were informed that NASA's environmental professionals prepared the estimates without direction or oversight from the Office of the CFO. Specifically, we were advised that the Office of the CFO deferred to NASA's Environmental Management Division (EMD) as experts in the preparation of the estimates. As a result of this division of responsibility, NASA's EMD made interpretations of federal accounting requirements in isolation without input and oversight from the CFO's office. We also noted that the CFO's office and NASA Legal Counsel were not interacting with the Department of Justice attorneys who were managing third-party claims on behalf of NASA in a manner that would allow NASA to recognize those liabilities when they are probable and estimable, in accordance with guidance provided in "*Interpretation of Federal Financial Accounting Standards Interpretation No. 2, Accounting for Treasury Judgment Fund Transactions, an interpretation of Statement of Federal Financial Accounting Standards (SFFAS) No. 4 and No. 5.*"

Increased Guidance and Training Required

The preparation of NASA's unfunded environmental liability estimates requires an understanding of environmental cost estimating and related accounting guidance. During the audit, NASA indicated that its Remedial Project Managers lacked sufficient environmental cost estimating experience to adequately prepare the estimates. To mitigate this deficiency, NASA is implementing the use of the Integrated Data Evaluation and Analysis Library (IDEAL) cost-estimating software. IDEAL generates estimates through the use of parametric cost models. However, based on our review, the users did not have a sufficient understanding of how the IDEAL system worked. This was evidenced by their questions about the software and the correction of prior year estimates.

NASA's environmental personnel received minimal accounting guidance and training. This lack of guidance and training resulted in several findings including: estimating liabilities in a manner that was inconsistent with accounting guidance on "probable" and "reasonably estimable"; inadequate quantification, categorization and tracking of changes in the year-to-year estimation process; lack of quantification and disclosure of "possible" environmental liabilities for financial statement purposes; improper presentation of a range of environmental estimates in financial statements; and improperly accruing for environmental liabilities associated with NASA-owned tanks and landfills.

NASA recently issued guidance in June 2004; however, not all centers/facilities were familiar with the guidance on probable and reasonable, and estimable determinations contained within this document.

Documentation to Support Liability Need Improvements

NASA did not consistently document the assumptions it used to prepare its unfunded environmental liability estimates. During our audit testing, NASA's environmental personnel often could not explain or provide documentation as to how, or why, they selected a specific estimate at several of its centers/facilities. Also, during the audit we were told that there was limited sharing of experiences/information between centers/facilities to ensure that similar liabilities at different locations were estimated consistently within NASA.

Insufficient Quality Control over Center Estimates

During the audit we could not find evidence to support that NASA performed an independent quality review of the unfunded environmental liability estimates prepared by the centers/ facilities. While NASA's environmental personnel at Headquarters did perform a review of the estimates, we observed errors that may have been identified had a more formal review occurred. For example, we noted the inclusion of certain costs associated with funded liabilities and installed equipment in the unfunded environmental liability estimates.

We also observed that the organizational structure described earlier allowed the Environmental personnel to make accounting decisions without oversight from the Office of the CFO. This included using a higher end estimate, when no point in the range is better than any other. NASA environmental personnel described this use of "higher-end" estimates as being "conservative." This is not consistent with Federal Financial Accounting and Auditing Technical Release Number 2.

Finally, we believe it is important that the IDEAL model be periodically reconciled with actual spending to validate the model. Currently, IDEAL has not been validated and accredited for estimating NASA remediation scenarios in accordance with OMB and NASA guidelines. NASA indicated that some models within IDEAL were evaluated under a Department of Defense (DOD) contract. However, a review by the DOD's Office of Inspector General indicated similar concerns regarding validation of the model.

Recommendation

We recommend that NASA document the process that it uses to prepare its unfunded environmental liability estimates. After the process is outlined, NASA should perform an analysis to help ensure the proper NASA personnel are participating. The analysis should help identify who in the process has responsibility and authority and who should be consulted and informed for each step. The benefit of this approach is that it would allow the CFO's office to determine the level of organizational integration among departments and where in the process input from the CFO's office is needed.

NASA has numerous policies, procedures and reports. To support the centers/facilities in the preparation of these estimates, NASA should conduct a gap analysis for each step of the newly outlined process to determine where there is conflicting or inadequate information or training. NASA should then develop an "evergreen" document of the current policies, procedures, guidance and training that is available in preparation of the estimate. This should be reviewed at an annual training conference.

NASA should also validate the tools (including IDEAL) and methodology used at the center/facility level to prepare the unfunded, environmental liability estimates.

OTHER MATTERS

Summary of FY2003 Material Weaknesses and Reportable Conditions

Issue Area	Summary Control Issue	FY 2004 Status
Material Weaknesses:		
NASA lacks sufficient audit trail to support that its FY 2003 Financial Statements are presented fairly	Documentation regarding significant accounting events, recording of non-routine transactions and post closing adjustments, as well as correction and other adjustments made in connection with data conversion issues must be strengthened	Modified Repeat Condition
NASA lacks effective Internal Controls surrounding its Fund Balance with Treasury Reconciliations	Supporting documentation to support application of rigorous reconciliation processes was not available. Unreconciled differences were identified in the FY 2003 year-end reconciliations	Modified Repeat Condition
NASA processes for preparing its Financial Statements still require improvement	Processes to prepare financial statements were not executed in a sufficiently timely and rigorous manner to support meeting reporting deadlines established by OMB	Modified Repeat Condition

Issue Area	Summary Control Issue	FY 2004 Status
Material Weaknesses:		
NASA still lacks adequate controls to reasonably assure that Property, Plant and Equipment and Materials are presented fairly in the Financial Statements	Controls relating principally to contractor-held PPE and materials and NASA-held Assets in Space and WIP need improvement; headquarters oversight needs improvement	Modified Repeat Condition
Reportable Conditions:		
Security Controls in NASA's Financial Statements Environment need improvement	IFMP Security Design and Implementation needs improvement, IFMP Security and General IT controls need to be strengthened, Oversight function supporting IFMP Security program needs improvement	Modified Repeat Condition, classified as material weakness in FY 2004 due in part to segregation of duties issues and interaction with weaknesses in financial management control processes

* * * * * * * * *

In addition, with respect to NASA's internal control over Required Supplementary Stewardship Information (RSSI) and performance measures reported in the Management, Discussion and Analysis, we were unable to apply certain procedures prescribed by OMB Bulletin No. 01-02, because of the limitations on the scope of the audit of the financial statements, as discussed in our Report of Independent Auditors, dated October 29, 2004. Further, we did not audit and do not express an opinion on such controls.

We also noted certain other matters involving internal controls that we will report to NASA management in a separate letter dated October 29, 2004.

This report is intended solely for the information and use of management and Office of Inspector General of NASA, OMB, and Congress, and is not intended to be and should not be used by anyone other than these specified parties.

Ernst + Young LLP

October 29, 2004
Washington, D.C.

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Report on Compliance with Laws and Regulations

To the Administrator and the Office of Inspector General
of the National Aeronautics and Space Administration:

We were engaged to audit the consolidated financial statements of the National Aeronautics and Space Administration (NASA) as of September 30, 2004, and have issued our report thereon dated October 29, 2004. The report states that because of the matters discussed therein, the scope of our work was not sufficient to enable us to express, and we do not express, an opinion on the consolidated balance sheet as of September 30, 2004, and the related consolidated statement of net costs, statements of changes in net position and financing, and combined statement of budgetary resources for the fiscal year then ended.

The management of NASA is responsible for complying with laws and regulations applicable to NASA. We performed tests of its compliance with certain provisions of laws and regulations, noncompliance with which could have a direct and material effect on the determination of financial statement amounts, and certain other laws and regulations specified in Office of Management and Budget (OMB) Bulletin No. 01-02, *Audit Requirements for Federal Financial Statements*, including the requirements referred to in the Federal Financial Management Improvement Act (FFMIA) of 1996. We limited our tests of compliance to these provisions, and we did not test compliance with all laws and regulations applicable to NASA.

Under FFMIA, we are required to report whether NASA's financial management systems substantially comply with Federal financial management systems requirements, applicable Federal accounting standards, and the U.S. Government Standard General Ledger at the transaction level. To meet this requirement, we performed tests of compliance with FFMIA section 803(a) requirements. However, as noted above, we were unable to complete our audit. Based upon the results of the tests we were able to complete, we noted certain instances, described below, in which NASA's financial management systems did not substantially comply with certain requirements:

- The NASA accounting system lacks integration and does not conform to the requirements currently specified by the Joint Financial Management Improvement Program. As identified in Footnote Sixteen to the financial statements, NASA's management continues to identify data integrity and configuration issues in the Core Financial system which results in inappropriate transactional postings. Additionally, the core financial system is unable to provide detailed listings of balances to support NASA's September 30, 2004, reported balances for accounts receivable, accounts payable and undelivered orders. Finally, certain subsidiary systems, including property, are not integrated with the Core Financial system.

- Issues with the Core Financial System continue to hinder NASA's ability to identify and resolve certain issues with its Fund Balance with Treasury amounts.

- Data within NASA's financial system have not been validated as reliable and may not be reliable to support NASA's financial statements.

- Weaknesses identified in NASA's financial management systems' access and application controls are significant departures from requirements specified in OMB Circulars A-127, *Financial Management Systems*, and A-130, *Management of Federal Information Resources.*

- Statement of Federal Financial Accounting Standards (SFFAS) No. 1, *Accounting for Selected Assets and Liabilities*, SFFAS No. 4, *Managerial Cost Accounting Concepts & Standards,* and NASA's Financial Management Requirements, require costs to be accrued in the period in which they are incurred and any corresponding liability to be recorded as an account payable, regardless of the associated amounts obligated. However, NASA has designed its new Core Financial Module to include a system edit whereby if costs (and the corresponding liabilities) are greater than the associated obligations, the difference is not recorded in NASA's general ledger until further research is performed. Instead, these differences are stored outside of its general ledger until additional funds are obligated and the excess costs (and the corresponding liabilities) can be recorded. Similarly, the Core Financial Module will not allow negative costs or downward adjustments to be recorded in the general ledger. We believe that NASA's accounting treatment of costs in excess of obligations and downward adjustments during fiscal years 2003 and 2004 represent noncompliance with the Federal accounting standards requirements and SGL requirements under FFMIA.

The Report on Internal Control includes information related to the financial management systems that were found not to comply with the requirements, relevant facts pertaining to the noncompliance, and our recommendations related to the specific issues presented. It is our understanding that management agrees with the facts as presented, and that relevant comments from the NASA's management responsible for addressing the noncompliance are provided as an attachment to this report.

Additionally, NASA has informed OMB of the status of its implementation of the Improper Payment Information Act of 2002 (IPIA). In its risk assessment, NASA identified and tested those payments related to firm-fixed price contracts from each of the Centers. Although the IPIA discusses consideration of other types of payments, NASA did not explicitly consider these payments as part of the risk assessment process or prepare an estimate of improper payments, but did note that audit efforts by nonfederal auditors with respect to grantees and by government auditors with respect to certain NASA contracts aid in identifying and mitigating improper payments. As of September 30, 2004, NASA may not have fully complied with the IPIA requirements.

Because we could not complete our audit, we were unable to determine whether there were other instances of noncompliance with laws and regulations that are required to be reported.

Providing an opinion on compliance with certain provisions of laws and regulations was not an objective of our audit and, accordingly, we do not express such an opinion.

This report is intended solely for the information and use of the management and Office of Inspector General of NASA, OMB, and Congress, and is not intended to be and should not be used by anyone other than these specified parties.

Ernst & Young LLP

October 29, 2004
Washington, D.C.

National Aeronautics and
Space Administration

Headquarters
Washington, DC 20546-0001

November 9, 2004

Reply to Attn of:

Office of the Chief Financial Officer

TO: Inspector General

FROM: Chief Financial Officer

SUBJECT: Management Response to Report of Independent Auditors

We appreciate the efforts of the Office of Inspector General, and its contractor Ernst & Young, LLP, to audit National Aeronautics and Space Administration's (NASA) FY 2004 balance sheet and accompanying financial statements. We acknowledge that, because of data integrity issues, internal control challenges, and residual system conversion matters, you were not able to express an opinion on the FY 2004 balance sheet and accompanying statements.

Your audit report identified four material weaknesses – Financial Systems, Analysis, and Oversight; Fund Balance with Treasury; Property; and Integrated Financial Management Program (IFMP) Core Financial module Control Environment – and numerous recommendations to resolve those weaknesses. All of these identified weaknesses are inherent in a financial system migration of this magnitude. NASA has taken the important step to streamline the financial operations and management information systems. By doing so, the effort has revealed systemic problems that were not apparent over the past decade. While clean opinions might have resulted from maintaining the old systems and procedures, keeping the status quo would have resulted in the same systemic challenges being perpetuated. This is an opportunity to create a solid foundation for the future and we appreciate your support throughout this process.

Our challenges are many, but we are determined to significantly improve our internal management control environment and to produce auditable financial statements that provide timely and relevant financial information to the NASA leadership and external stakeholders. We will aggressively assess and implement all recommendations made by Ernst & Young, LLP, and will work with your office to develop and implement corrective action plans that are responsive and measurable to demonstrate that we are moving forward in reforming financial management at NASA and adhering to the recommendations of the FY 2004 audit findings.

Again, I appreciate all of your support and assistance as NASA continues the journey towards attaining the goal of being the "Best in Government" when it comes to financial management operations. It is a tough journey but one worth the trip – as the results will place the Agency in a solid position to meet the new vision of – moon, Mars and beyond.

Cordially,

Gwendolyn Sykes

Gwendolyn Sykes

Appendices

Appendix 1: Office of the Inspector General Summary of Serious Management Challenges

National Aeronautics and
Space Administration

Office of Inspector General
Washington, DC 20546-0001

OCT 29 2004

TO: Administrator

FROM: Inspector General

SUBJECT: Most Serious Management and Performance Challenges

These are our views, pursuant to the Reports Consolidation Act of 2000, of NASA's most serious management and performance challenges. These challenges include areas where management is working to improve Agency programs by implementing recommendations of the Columbia Accident Investigation Board (CAIB), providing for effective financial management, and enhancing controls over assets and information technology. We believe that meeting these challenges is critical in building a sound foundation for implementing the President's Space Exploration Vision in the years to come. The four challenges are listed below and summarized in the enclosure.

- Correcting serious cultural, organizational, and technical deficiencies that will enable the Space Shuttle to return to flight safely
- Achieving U.S. Core Complete on the International Space Station with the uncertain timing of Space Shuttle operations
- Ensuring that the integrated financial management system improves NASA's ability to allocate costs to programs, efficiently provides reliable information to management, and supports compliance with the Chief Financial Officers Act
- Continuing efforts to enhance information technology security by addressing weaknesses in controls

In previous years, we identified the need to improve controls over property held by Agency contractors as a separate challenge but this year we are addressing it as an element within the overall financial management challenge. We believe this is more appropriate given the amount of NASA property held by contractors and the relative importance of this issue to NASA's ability to improve financial management.

We also deleted the following challenge that we included last year: "Ensuring NASA's facilities are efficiently used and contribute to fulfillment of the Agency's mission." While facilities remain an important issue for the Agency, we do not believe that the challenge is as serious as the other management and performance issues we have identified. Also, NASA formed a Real Property Mission Analysis Team that is reviewing facilities at all Centers and will make recommendations to senior Agency officials on improving facilities management. The team is considering observations from a prior Facilities Tiger Team (that conducted an initial review of facilities) and from NASA's real property business plan (which lists improvements needed to better manage the Agency's facilities and land). We will continue to monitor facilities issues as the Agency moves to implement the Space Exploration Vision.

If you have any questions, or need additional information, please call me at 202-358-1220.

Robert W Cobb

Robert W. Cobb

Enclosure

NASA's Most Serious Management and Performance Challenges

Correcting serious cultural, organizational, and technical deficiencies that will enable the Space Shuttle to return to flight safely.

The Columbia Accident Investigation Board (CAIB) conducted an extensive examination of the February 1, 2003, loss of the Space Shuttle *Columbia* and its seven-member crew. NASA has significant actions underway to address the CAIB recommendations, including establishment of a Return-to-Flight (RTF) Planning Team, Space Flight Leadership Council, and RTF Task Group. Safely returning the Shuttle fleet to flight will require that the Agency address numerous organizational and technical challenges. Unintended consequences of changes will have to be contemplated. Also, NASA will need to exercise due diligence to ensure that engineering and safety decisions are not unreasonably affected by the cost and schedule pressures associated with events outside the Shuttle Program's control, such as budget decisions or supply shortages on the International Space Station. In addition, the Shuttle fleet is aging and will eventually be replaced by a new transportation system. Sustainability of reasonably safe flight in the context of program closeout will be an additional challenge that the Agency must address.

As of October 29, 2004, the RTF Task Group has conditionally closed 5 of the 15 RTF recommendations made by the CAIB. NASA still has substantial work to perform in addressing technical issues raised by the CAIB. For example, NASA recently determined that the size of the maximum foam debris that can be shed from the external tank must be about 25 percent smaller than the debris size previously thought to be acceptable. NASA faces additional challenges with the on-orbit inspection and repair of tile and reinforced carbon-carbon (RCC) panels. The Shuttle Program has yet to fully align the Orbiter Boom Sensor System with the evolving on-orbit detection requirements for damage to tile and the RCC. While testing is currently being conducted to better define both, there is concern that the two may not fully converge along the current RTF timeline. Also, NASA is pursuing multiple tile and RCC repair concepts. However, these repair concepts are expected to have limitations and are too early in development to forecast a completion date. For example, NASA has encountered problems applying the tile repair material in a vacuum.

The CAIB report also found that organizational issues and culture were as much a cause of the *Columbia* accident as the external tank foam. Because of the critical importance of organizational and cultural changes, the CAIB required that NASA prepare a detailed plan for addressing those issues prior to returning to flight. The Administrator has stated that the issue is sufficiently important that implementation of the plan must take place prior to return to flight. To address the CAIB's concerns, the Associate Administrator for Safety and Mission Assurance released a draft plan to address the organizational causes of the Columbia accident. The plan was to serve as the basis for establishing independent technical authority and safety functions for all NASA Enterprises. However, during September 2004, the NASA Administrator advised senior Agency officials that the draft Independent Technical Authority (ITA) plan must be significantly revised. Agency oversight groups had objected to various

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provisions in the draft plan. Accordingly, NASA still has work to do to design an acceptable ITA plan. The Deputy Chief Engineer is in the process of revising the plan.

As part of our ongoing review of RTF activities, we also identified management challenges related to the safety and quality assurance of space flight hardware. For example, our review of records for the Solid Rocket Booster bolt catchers manufactured from 1995 through 1998 identified several deficiencies. We found that the Defense Contract Management Agency (DCMA) did not perform mandatory hardware inspections on bolt catchers used in Space Shuttle operations. When inspections were performed, we found that DCMA Quality Assurance Representatives were not always adequately trained to perform the types of inspections delegated. We also found that NASA relied entirely on DCMA to provide surveillance of bolt catcher manufacturing without the oversight that NASA regulations required. Because of the flawed inspection process, DCMA should have rejected all of the bolt catchers manufactured from 1995 to 1998, including those used on the Space Shuttle *Columbia* during STS 107. The CAIB also identified problems with certification, quality assurance, and safety margins for bolt catchers and recommended that NASA test and qualify flight hardware bolt catchers prior to returning to flight.

Achieving U.S. Core Complete on the International Space Station with the uncertain timing of Space Shuttle operations.

Uncertainties about the timing for returning the Shuttle fleet to flight and resuming servicing mission for the International Space Station (ISS) will pose formidable challenges for achieving U.S. Core Complete and managing the ISS Program schedule and cost. NASA's ISS corrective action plan, which was prepared prior to the *Columbia* accident, does not consider the schedule and cost impact of the Shuttle fleet's grounding on the ISS Program. Because the core complete milestone slips further for each day the Shuttle fleet is grounded, the Program schedule is currently more than 2 years off track, and the cost impact will be significant. The $200 million budget cut to program reserves significantly reduces the financial margin recommended by the ISS Management and Cost Evaluation Task Force, adding more cost risk to a program with a history of cost overruns.

The ISS was designed to be resupplied by the Shuttle. Consequently, the ISS Program has been forced to deal with increasing operational and safety risks as a result of inadequacies in the current resupply capabilities. For example, the first of the four gyroscopes broke 2 years ago as a result of a bearing failure, and a second stopped working in April 2004 as a result of a power failure. Flight controllers had to rely on the remaining two gyroscopes (the minimum required) to keep the ISS correctly in orbit. ISS crewmembers repaired the second gyroscope during an extra-vehicular activity (EVA) that required both crewmembers to leave the interior of the ISS unattended for several hours and to traverse an unusually hazardous EVA route. Although three gyroscopes are now working, one has exhibited power surges and vibrations. NASA's plan to replace all of the gyroscopes with newer models must await resumption of Shuttle flights because the gyroscopes are too large for the Russian's resupply vehicle, "Progress." In addition, the ISS has experienced difficulty with the Russian-made Elekron oxygen-generating unit, which processes the crew's breathing oxygen. After several attempts, the crew partially restored the unit's operation.

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Ensuring that the integrated financial management system improves NASA's ability to allocate costs to programs, efficiently provides reliable information to management, and supports compliance with the Chief Financial Officers Act.

During fiscal year (FY) 2003 NASA completed its implementation of the Integrated Financial Management Program (IFMP) Core Financial Module to replace the 10 separate legacy accounting systems. The Core Financial Module is the backbone of the IFMP, providing a NASA-wide, fully integrated accounting system that the Agency previously lacked. The new system was intended, among other things, to produce auditable financial statements and eliminate reporting weaknesses identified in prior year financial statement audits. However, serious deficiencies continue to exist.

NASA has been unable to generate useful financial statements from data in the Core Financial Module. The system-generated statements contained fundamental errors and data upon which management could not rely. These errors included a Balance Sheet that did not balance, line items within the Statement of Budgetary Resources that did not equal, and different amounts for the same line item on two separate financial statements. As a result, interim financial statements submitted to the Office of Management and Budget were developed using estimates. The FY 2004 year-end statements note that many accounts are misstated due to data integrity issues from FY 2003. NASA has specifically identified misstatements in amounts reported on the Statement of Budgetary Resources and has indicated that data are not available to prepare required supplementary information on the Agency's major budget accounts.

In August 2004, the independent auditor notified the Office of Inspector General and NASA management that a disclaimer of opinion would be issued on the FY 2004 financial statements. In addition to the lack of auditable financial statements and unreliable data within the Core Financial Module, the independent auditor identified deficiencies with policies and procedures and audit documentation in critical areas. The independent auditor found inconsistencies in NASA's policies and procedures in the accounting for environmental liabilities, along with the insufficiency of documentation to support amounts recorded. In the property area, questions have been raised about a $1.7 billion adjustment to properly classify research and development costs that were previously capitalized, as well as the accounting for internal use software, specifically the cost of the IFMP.

As in the last 3 years, NASA's independent auditor reported that the Agency's controls over contractor-held property, plant, and equipment are weak and do not ensure that information provided for inclusion in the financial statements is reliable and complete. NASA is placing significant reliance on contractor reporting. Although NASA implemented a plan to have the Defense Contract Audit Agency perform internal control reviews at NASA contractors, most of the reviews are based on information as of March 31, 2004, and will not include tests of transactions for the subsequent period through September 30, 2004. Until NASA successfully implements a single, integrated system for reporting contractor-held property, the Agency will continue to experience problems with the consistency of information reported by its contractors.

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NASA must also address a significant human capital shortage in the Office of the Chief Financial Officer (OCFO). About 40 percent of the positions in the OCFO are unfilled, including three key leadership positions. Without sufficient and adequately trained staff, the office will not be able to provide effective leadership to implement policies and procedures, perform oversight of financial management at NASA centers, and monitor the quality of data generated by the financial system. In addition, staffing shortages in key leadership positions may limit the ability of the OCFO to adequately monitor contractors hired to alleviate staffing vacancies.

Continuing efforts to enhance information technology security by addressing weaknesses in controls.

NASA's leadership has implemented several information technology security (ITS) improvements, and these positive changes should help improve NASA's overall ITS posture. However, many ITS challenges remain. Specifically, our audits and assessments found recurring and significant internal control weaknesses related to ITS, including unclear system administrator roles and responsibilities; untested contingency plans; a lack of alternate processing facilities; and inadequate implementation of host and network security, system risk assessments, system certifications, and vulnerability testing.

In addition, the independent auditor for NASA's FY 2003 financial statement audit identified several ITS deficiencies relating to the general controls environment over information technology architecture that processes financial applications. Preliminary results of the independent auditor's FY 2004 financial statement audit have also identified similar ITS deficiencies.

Because of the sensitivity of ITS vulnerabilities, we are not providing details on specific weaknesses in this document. However, we have provided the Agency detailed information on vulnerabilities and recommendations for corrective action in reports and other controlled correspondence.

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Appendix 2: Inspector General Act Amendments Reports

THE INSPECTOR GENERAL ACT AMENDMENTS

The *Inspector General Act Amendments of 1988* (P.L. 100-504) [the Act], require that Inspectors General (IG) and Agency Heads submit semi-annual reports to Congress on actions taken on audit reports issued by the Office of Inspector General (OIG). In compliance with the Act, NASA consolidated and annualized the relevant information for FY 2004, and the Agency's report follows.

REPORT ON AUDIT FOLLOW-UP

NASA management is committed to ensuring the timely resolution and implementation of OIG audit recommendations and believes that audit follow-up is essential to improving the efficiency and effectiveness of NASA programs, projects, and operations. Therefore, the Agency has implemented a comprehensive audit follow-up program to ensure that OIG audit recommendations are resolved and implemented in a timely manner.

In implementing its audit follow-up program, NASA utilizes the Corrective Action Tracking System version 2.0 (CATS II) as its primary database for monitoring OIG audit recommendations. CATS II is a Web-based application developed by NASA and maintained by the Management Systems Division.

NASA's audit follow-up program consists of a joint effort between NASA management and the OIG. As a direct result of this collaborative effort, NASA succeeded in reducing the number of open OIG audit recommendations by 75 percent from 453 recommendations in FY 2002 to 110 recommendations as of September 30, 2004. These 110 recommendations correspond to 36 audit reports that are pending final management action.

REPORTS PENDING FINAL ACTION ONE YEAR OR MORE AFTER ISSUANCE OF A MANAGEMENT DECISION

As of September 30, 2004, NASA had a total of 27 OIG reports containing 82 recommendations on which management decisions have been made, but final action has not been taken. Management continues to address diligently the recommendations put forth by the OIG. NASA is working actively to implement those recommendations.

AUDIT AND INSPECTION REPORTS PENDING FINAL ACTION
(As of September 30, 2004)

Report Number	Report Title	Report Date
IGMEMO12	Arthur Andersen Report on NASA's FY 1999 Financial Statements	02/20/2000
IG00034	Foreign National Visitors at NASA Centers	05/12/2000
IG00057	NASA's Planning and Implementation for Presidential Decision Directive 63—Phase I	09/28/2000
IG00055	System Information Technology Security Planning	09/28/2000
IG00059	Software Assurance	09/28/2000
G00021	Assessment of NASA's Use of the Metric System	02/20/2001
IGMEMO17	Oversight of NASA's FY 2000 Financial Statement Audit	02/26/2001
IG1021	X-37 Technology Demonstration Project Management	03/30/2001
IG1032	UNIX Operating System Security and Integrity in MCC JSC	08/22/2001
IG1038	NASA's Planning and Implementation for PDD 63	09/27/2001
G00017	Internet Based Spacecraft Commanding Security Issues	10/22/2001
IG02004	Approvals for Accessing Information Technology Systems at MSFC and GRC	11/19/2001
IG02011	International Space Station Spare Parts Costs	03/22/2002
IG02010	Telephone Management	03/26/2002
IG02017	Management of Research Grants and Cooperative Agreements	06/04/2002
IG02028	Space Launch Initiatives	09/30/2002
G02024	Assessment of the JPL Firewall and Other IT Security Measures	12/18/2002
IGMEMO23	FY 2002 NASA Financial Statement Audit	01/23/2003
IGMEMO14	QCR: Oversight of PriceWaterhouseCoopers, L.L.P., Audit of NASA's Financial Statements for the FY Ended September 20, 2001	01/24/2003
IGMEMO15	FY 2001 Management Letter Comments—Internal Control	01/24/2003
IGMEMO16	FY 2001 Management Letter Comments—IT	01/24/2003
IG03016	QCR: Johns, Bubbers & Johns, P.A., Audit of the KSC Exchange Financial Statements for the FY Ended September 30, 2000 and September 30, 2001	03/26/2003
IG03009	Performance Management Related to Agency-wide FY 2002 IT Security Program Goals	03/27/2003
IG03013	NASA Needs to Improve Waste Reduction Activities	05/30/2003
IG03017	Information Technology Incident Response Capability Needs Improvement	06/9/2003
IG03022	Follow-up of Disaster Recovery Planning	08/6/2003
IG03023	Failures in Cost Estimating and Risk Management Weaknesses in Prior Space Launch Initiatives	09/29/2003

STATISTICAL TABLE ON AUDIT REPORTS WITH DISALLOWED COSTS

(October 1, 2003 through September 30, 2004)

		Number of Audit Reports	Dollar Value
A	Audit reports with management decisions on which final action had not yet been taken at the beginning of the reporting period	0	$0
B	Audit reports on which management decisions were made during the reporting period	1	$30,563
C	Total audit reports pending final action during the reporting period (total of A + B)	1	$30,563
D	Audit reports on which final action was taken during the reporting period		
	1. Value of disallowed costs collected by management	1	$15,292
	2. Value of costs disallowed by management	0	$15,271
	3. Total (lines D1 + D2)	1	$30,563
E	Audit reports needing final action at the end of the reporting period (C–D3)	0	$0

STATISTICAL TABLE ON AUDIT REPORTS WITH RECOMMENDATIONS THAT FUNDS BE PUT TO BETTER USE

(October 1, 2003 through September 30, 2004)

		Number of Audit Reports	Dollar Value
A	Audit reports with management decisions on which final action had not yet been taken at the beginning of the reporting period	0	$0
B	Audit reports on which management decisions were made during the reporting period	1	$1,471,799
C	Total audit reports pending final action during the reporting period (total of A + B)	1	$1,471,799
D	Audit reports on which final action was taken during the reporting period		
	1. Value of disallowed costs collected by management	1	$1,471,799
	2. Value of costs disallowed by management	0	$0
	3. Total (lines D1 + D2)	1	$1,471,799
E	Audit reports needing final action at the end of the reporting period (C–D3)	0	$0

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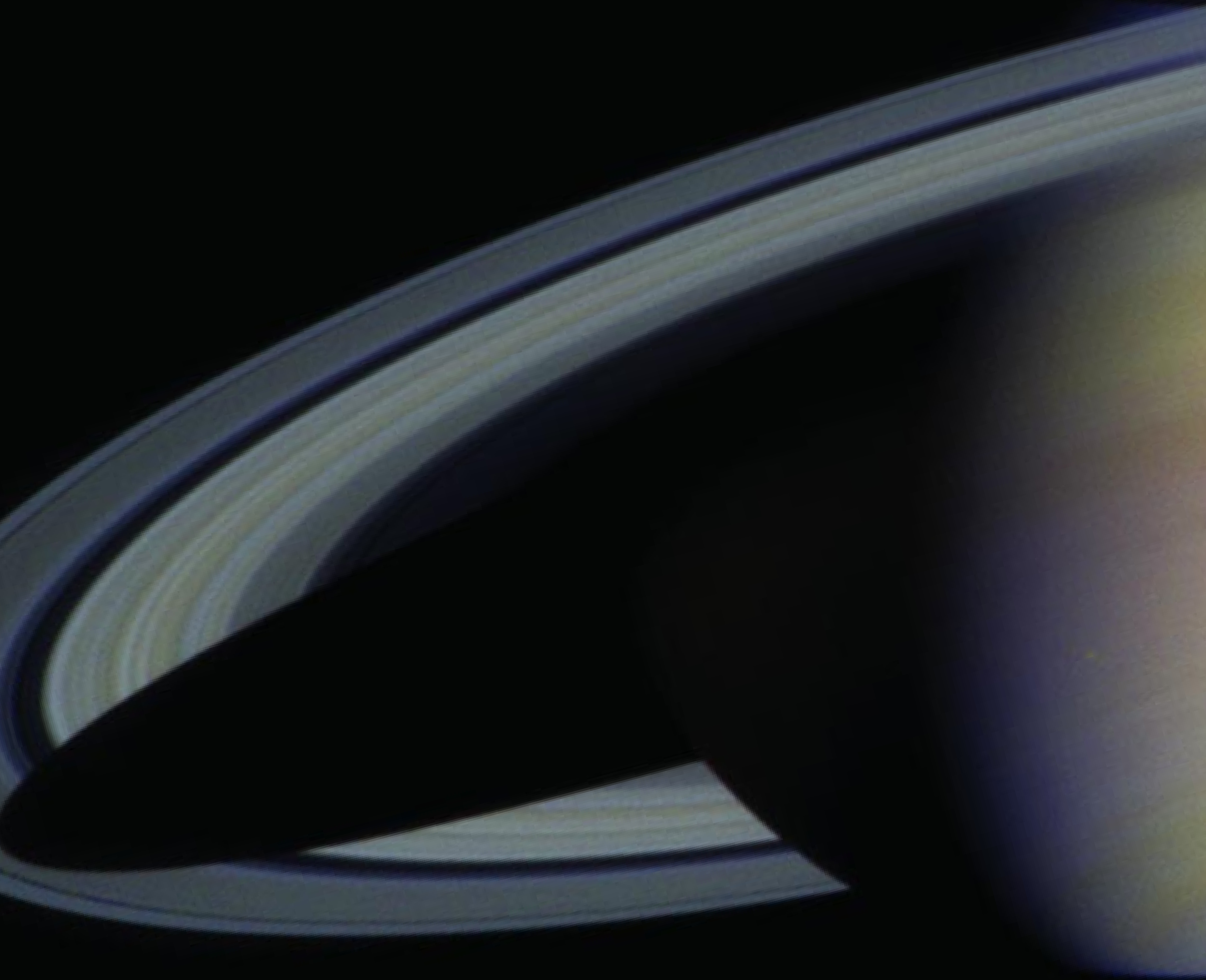
The Cassini–Huygens spacecraft took this image of Saturn as it approached the ringed planet in 2004.



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