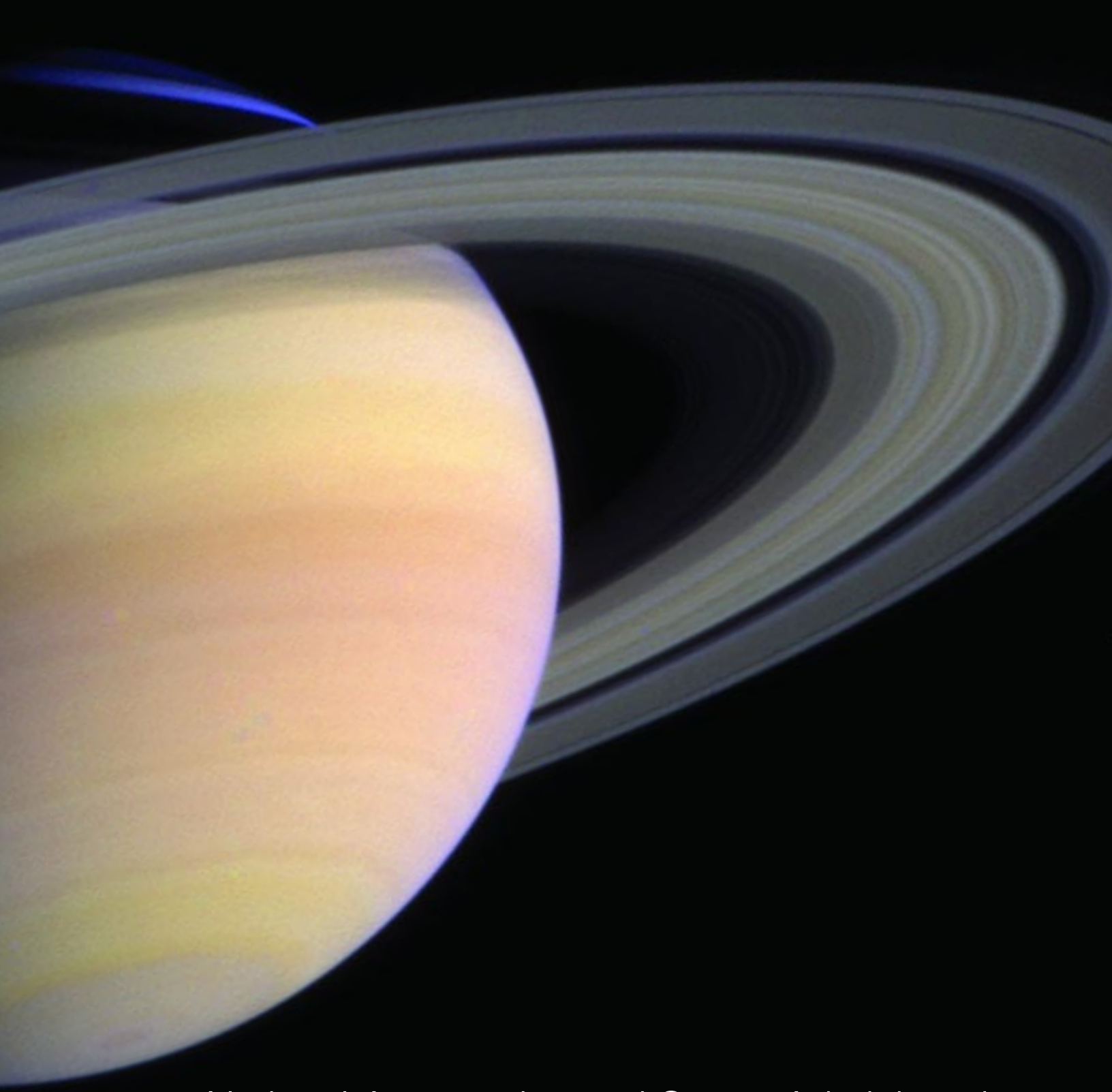


National Aeronautics and Space Administration

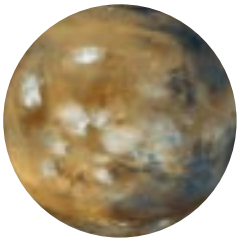
Fiscal Year 2004 Performance and Accountability Report

Introduction to NASA's Performance and Accountability Report

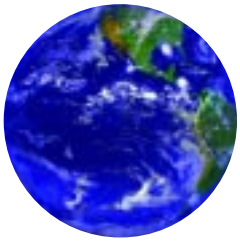
This is the National Aeronautics and Space Administration's (NASA) *Fiscal Year 2004* (FY 2004) *Performance and Accountability Report*. It is a detailed account of NASA's performance in achieving its annual goals and long-term objectives for its programs, management, and budget. It includes detailed 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:

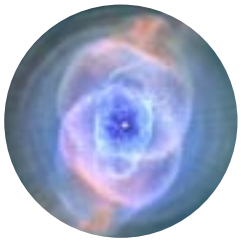


Part 1—Management Discussion and Analysis. Part 1 presents a snapshot of NASA's FY 2004 performance achievements. It focuses on the tools, capabilities, and accomplishments that make NASA the Nation's premier research and development agency for aeronautics and space. Part 1 also addresses financial and 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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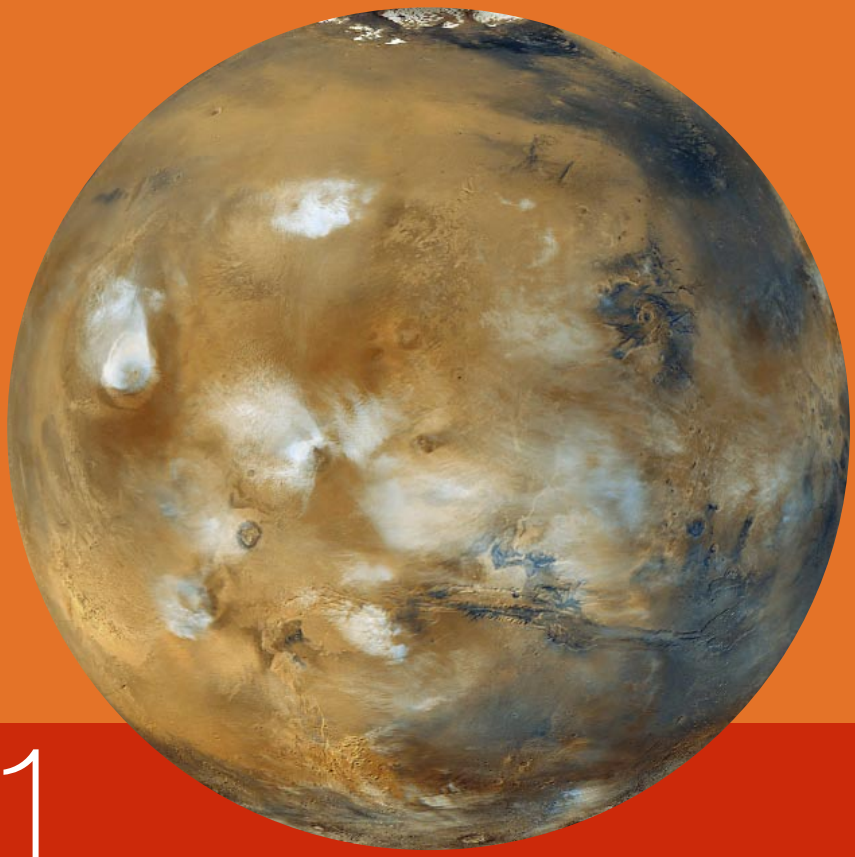


Part 1

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.

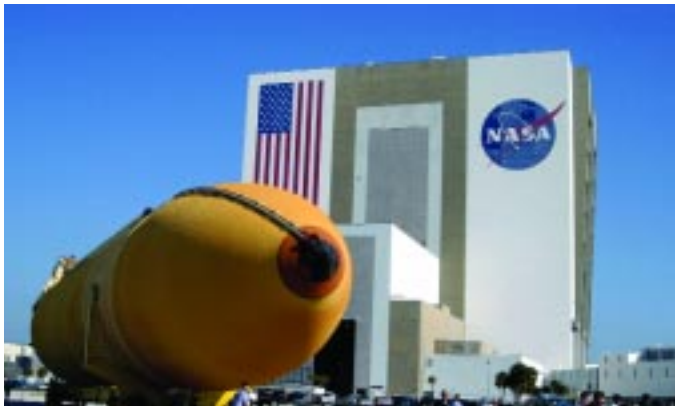


Figure 4: A Shuttle external tank was guided out of the Vehicle Assembly Building at Kennedy Space Center as it began its journey to the Michoud Space Systems Assembly Facility near New Orleans, Louisiana.

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.

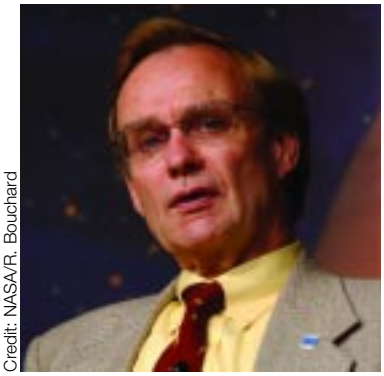
In January 2004, Jim Garvin was at NASA's Jet Propulsion Laboratory in Pasadena, California, with his colleagues to watch, tense and excited, as each rover came to an airbag-aided, bouncing, "soft" landing on Mars. He then marveled with millions of people throughout the world as *Spirit* and *Opportunity* 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:

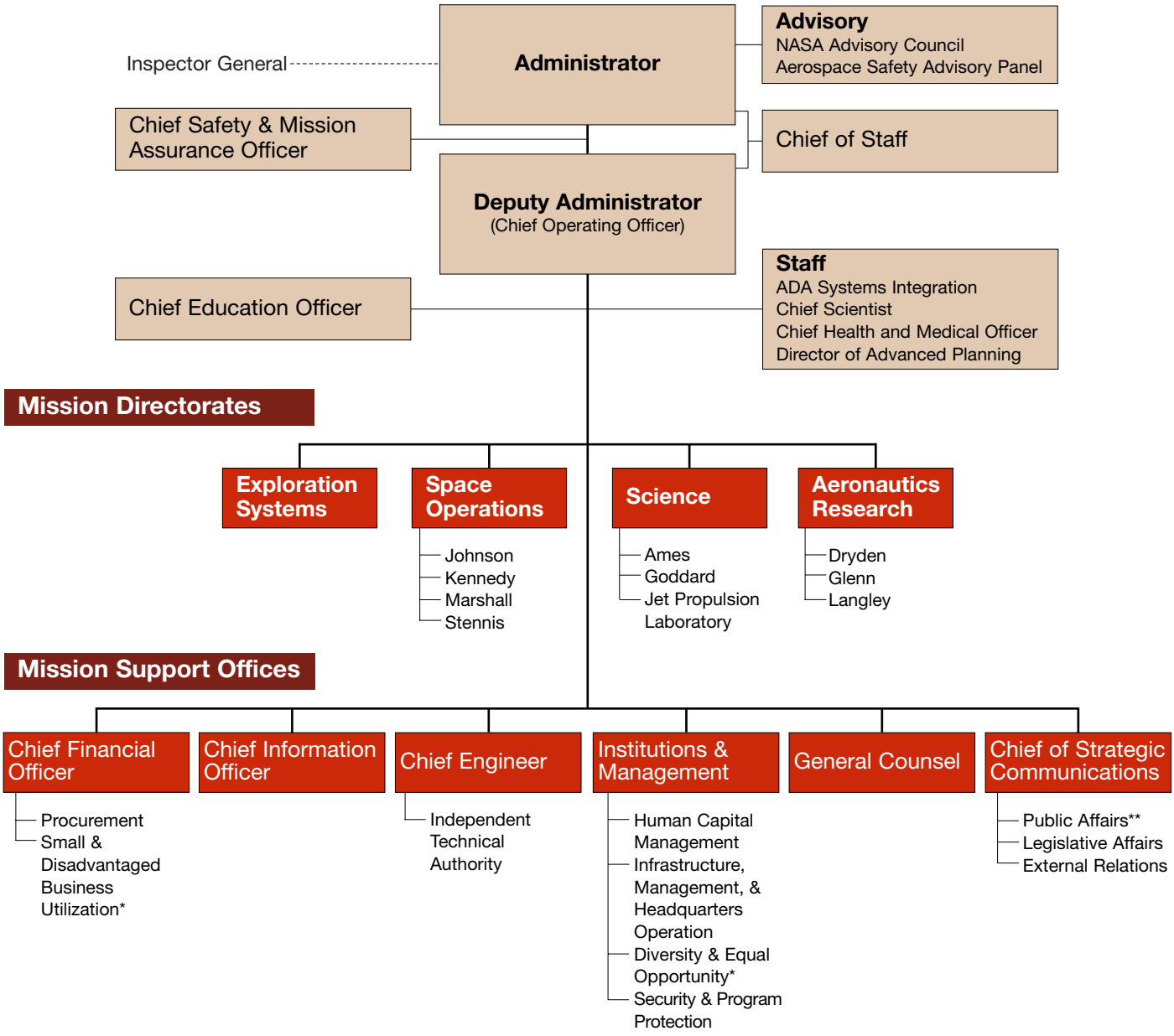
- Safety: NASA is committed, individually and as a team, to protecting the safety and health of the public, NASA's partners, NASA's people, and the assets that the public entrusts to the Agency. Safety is the cornerstone upon which NASA builds mission success.
- The NASA Family: NASA is a diverse team 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.

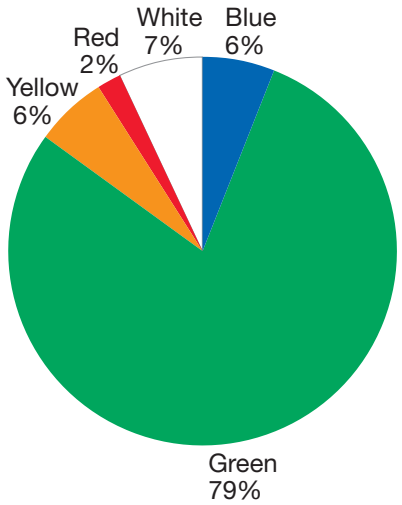


Figure 10: NASA achieved or exceeded 85 percent of the Agency's 233 Annual Performance Goals (APGs) in FY 2004.

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.

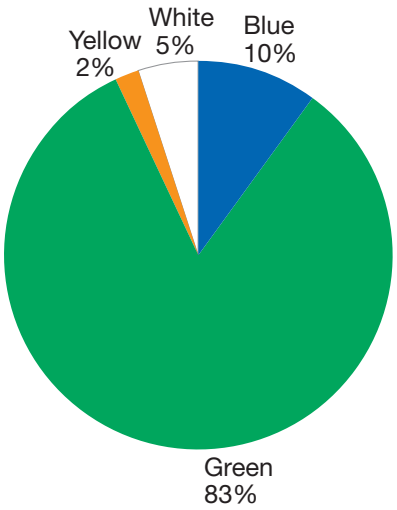


Figure 11: NASA is on track to achieve or exceed 93 percent of the Agency's 132 multi-year Outcome goals.

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.

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.

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.

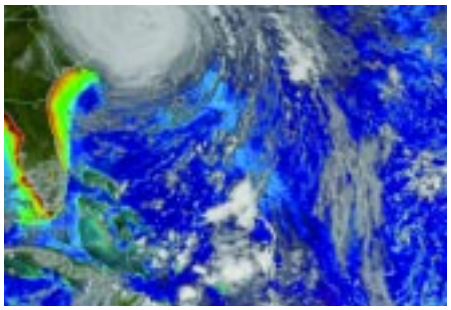
The changes in the composition of the atmosphere and its ability to absorb, reflect, and retain energy from the Sun affect the weather and climate on Earth. Aura's instruments will track both human-made and natural agents in Earth's atmosphere and will help scientists understand how atmospheric composition 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.

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

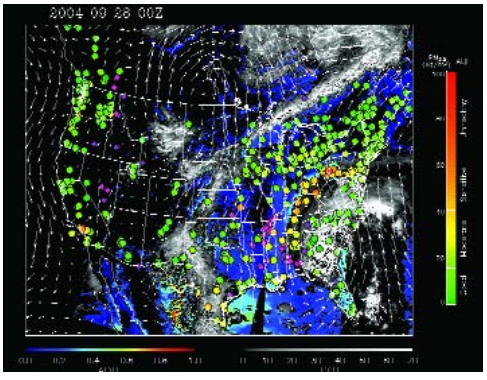
Figure 13: This SeaWiFS image of Hurricane Isabel on September 18, 2003, shows that as the hurricane passes, it leaves behind a trail of plankton blooms. The lighter blue areas represent higher amounts of chlorophyll and phytoplankton growth stimulated by the additional nutrients brought up to the surface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



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.

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.

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

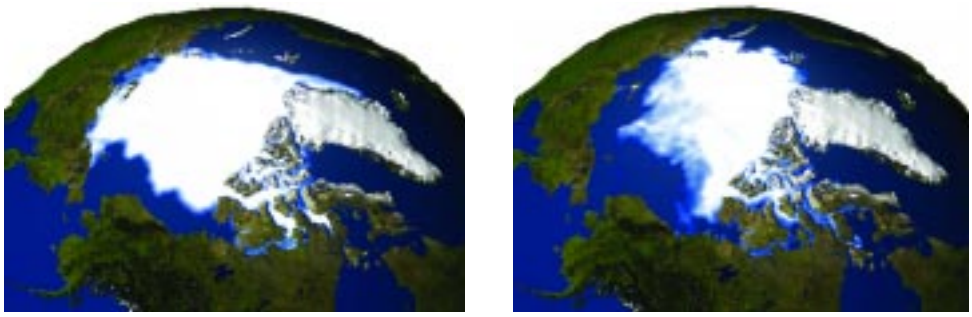


Figure 16: These images illustrate the magnitude of the difference in ice cover, which is about 1.6 million km², between 1980 and 2003. The comparisons show a dramatic decrease in the Arctic's ice cover.

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.

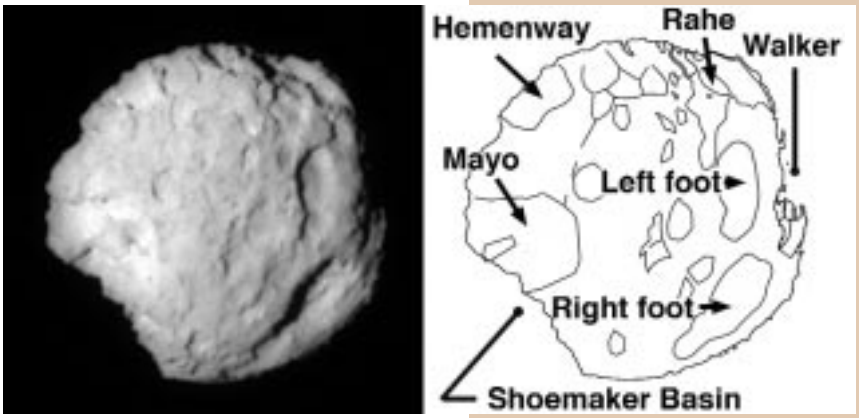
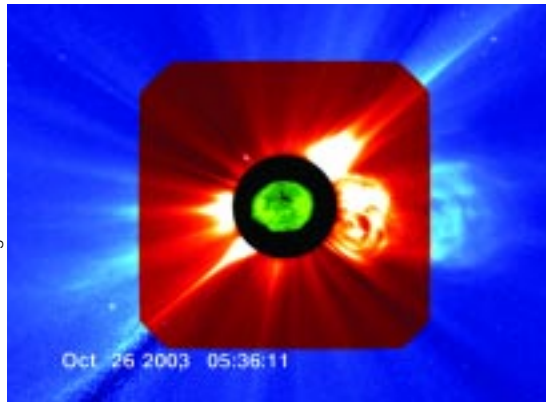


Figure 17: These images illustrate the magnitude of the difference in ice cover, which is about 1.6 million km², between 1980 and 2003. The comparisons show a dramatic decrease in the Arctic's ice cover.

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

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

GOAL 2
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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.

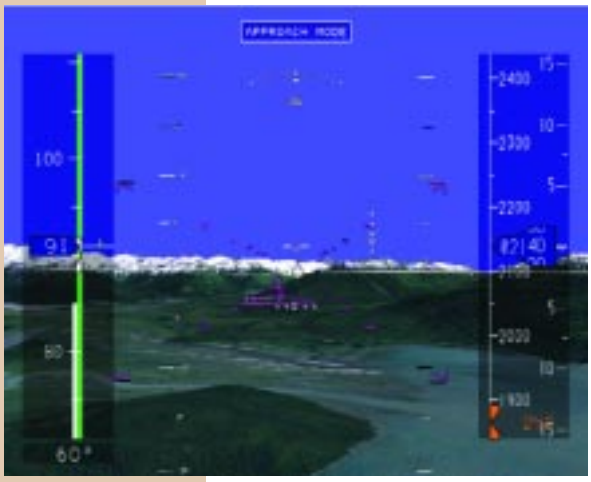

Figure 20: Simulations and flight studies show that the Synthetic Vision System increases pilot situational awareness and reduces errors and workload.

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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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

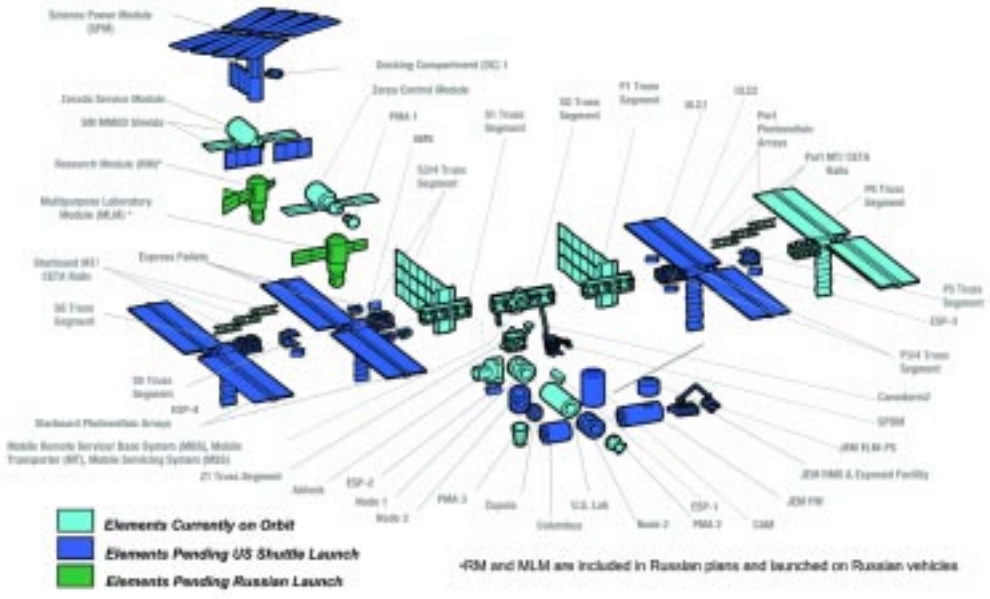

Figure 23: The ISS technical station configuration endorsed at the July 2004 meeting.

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.

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 super-computing 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.

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.

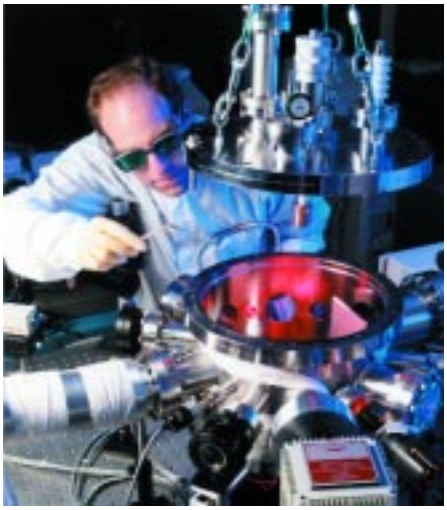


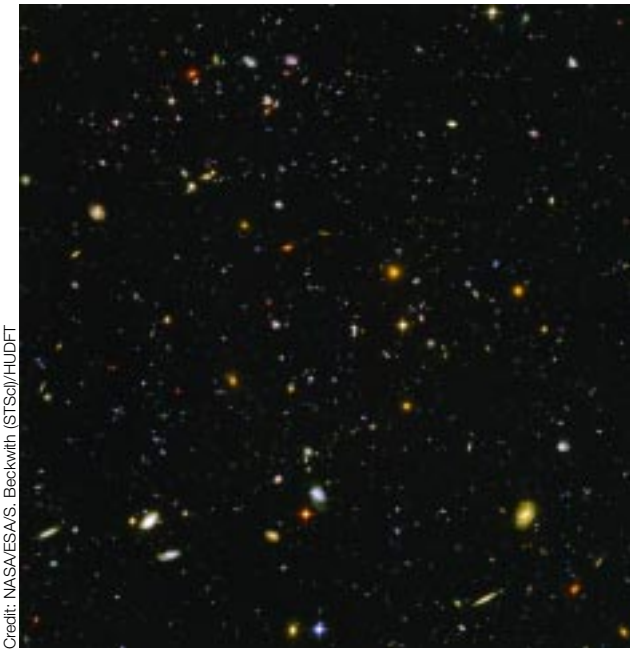
Figure 26: NASA's Electrostatic Levitator is a unique tool—one of only a few in the world—that allows researchers to study molten materials, such as metals, alloys, and metallic glass, in a containerless environment here on Earth. The levitator keeps the sample in a perfectly spherical shape, making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

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.

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

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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

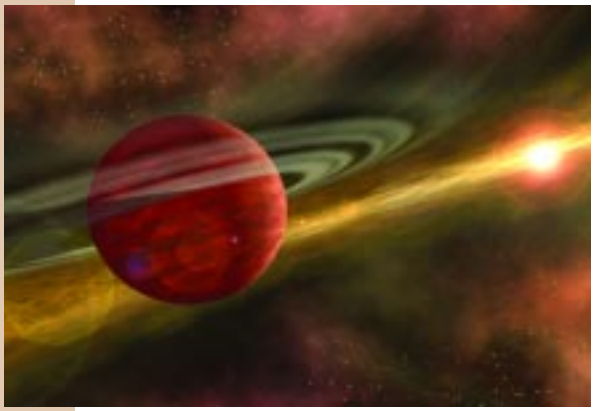


Figure 29: An artist's concept shows a newly formed planet clearing a path through the dusty disc encircling a young star.

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

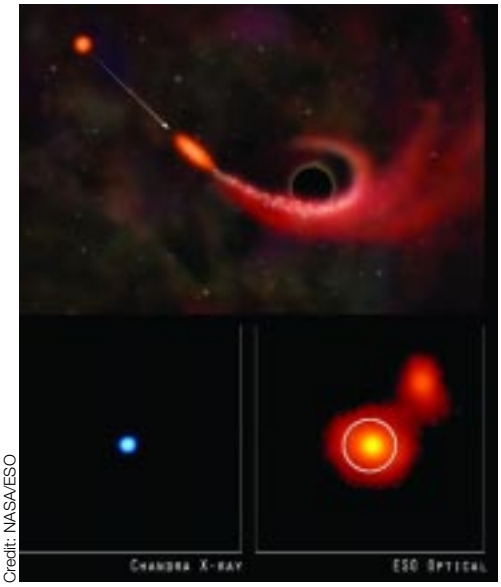
Figure 30: Spitzer imaged the most prolific birthing ground in the Milky Way, a nebula called RCW 49. Because the multitude of stars are hidden behind clouds of dust, they cannot be seen at visible wavelengths. Spitzer's infrared array camera was able to see past the cloud to find older stars (blue),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

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.

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.

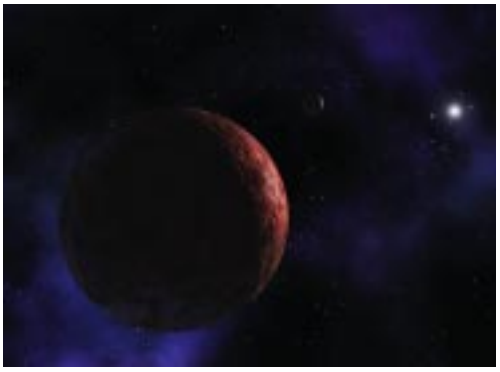


Figure 32: An artist's illustration of Sedna shows its extreme distance from the Sun, which appears as a bright star. Between Sedna and the Sun is a hypothetical small moon that scientists believe may be circling the distant planet-like body.

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.*

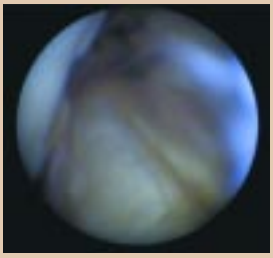


Figure 33: The system (below) provided this view of an Anterior Cruciate Ligament inside a knee.

Credit: Micro Medical Devices, Inc.

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.

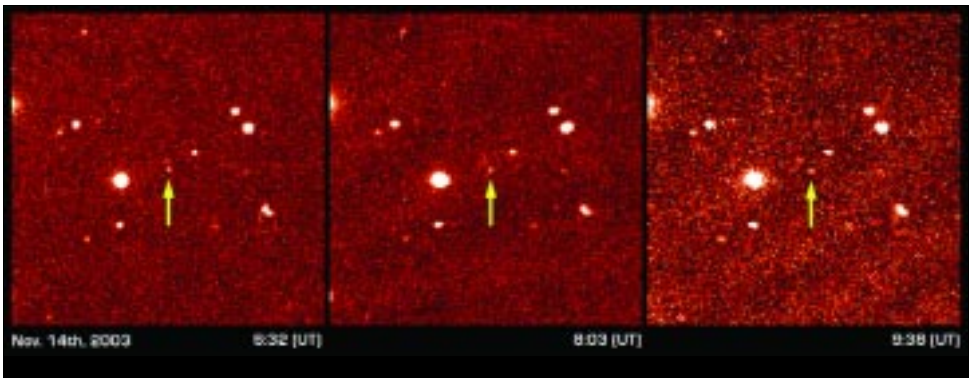
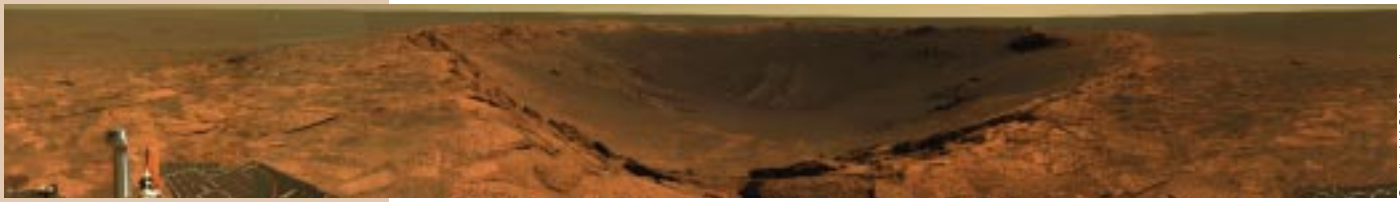


Figure 34: These three pictures show the first detection of Sedna. Imaged on November 14, 2003, from 6:32 to 9:38 Universal Time, Sedna (marked by the arrow) was identified by the slight shift in position over time.

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.



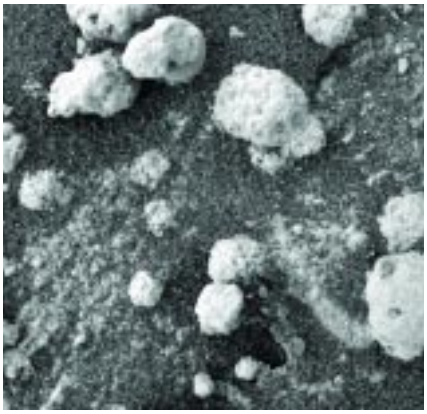
Credit: NASA/Cornell

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.

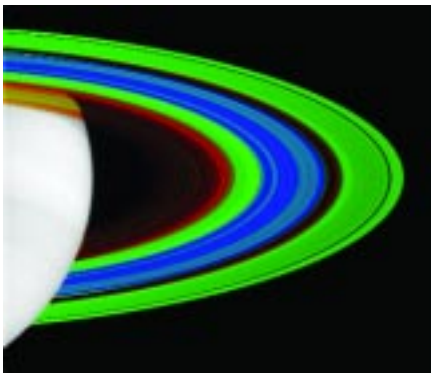


Figure 37: The varying temperatures of Saturn's rings are depicted here in this false-color image from the Cassini spacecraft. The image was made from data taken by Cassini's composite infrared spectrometer instrument. Red represents temperatures of about minus 261 degrees Fahrenheit, and blue minus 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

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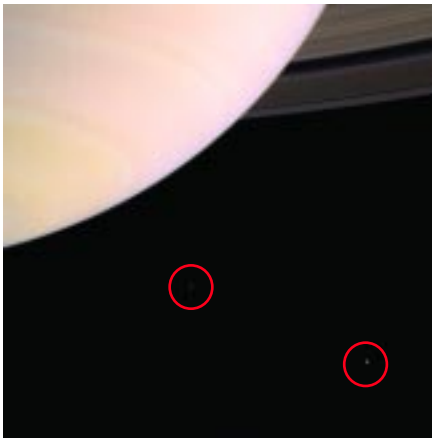
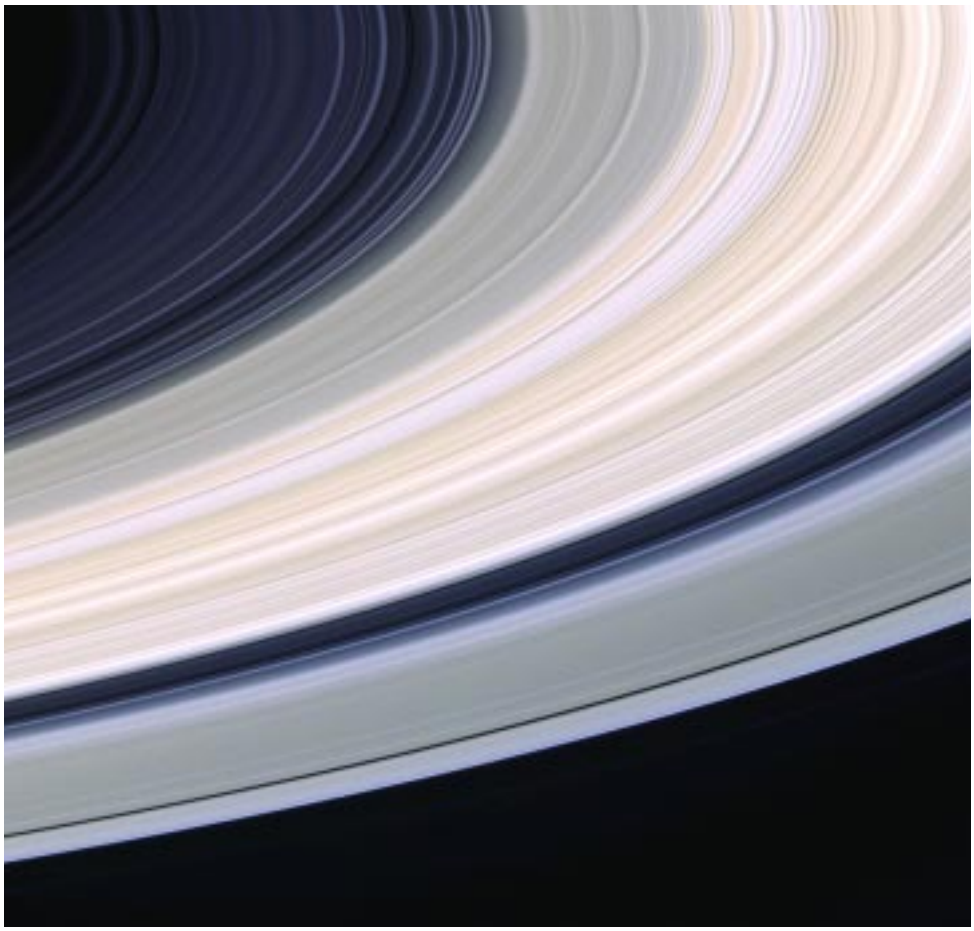


Figure 38: Saturn's atmosphere is prominently shown with the rings emerging from behind the planet at the upper right. The two moons near the bottom of the image are Mimas and Enceladus. This image was taken on August 8, 2004, with the Cassini spacecraft narrow angle camera in red, green, and blue filters. 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.

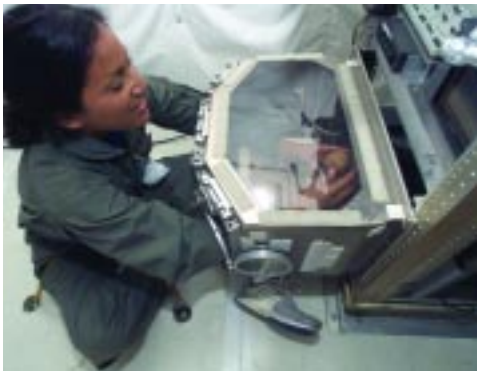


Figure 41: NASA Explorer School educator Alissa Kuseske uses a small glovebox to perform her students' spinning tops experiment onboard the KC-135. The glovebox kept the tops from floating around the cabin during the jet's roller coaster-like dives.

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."

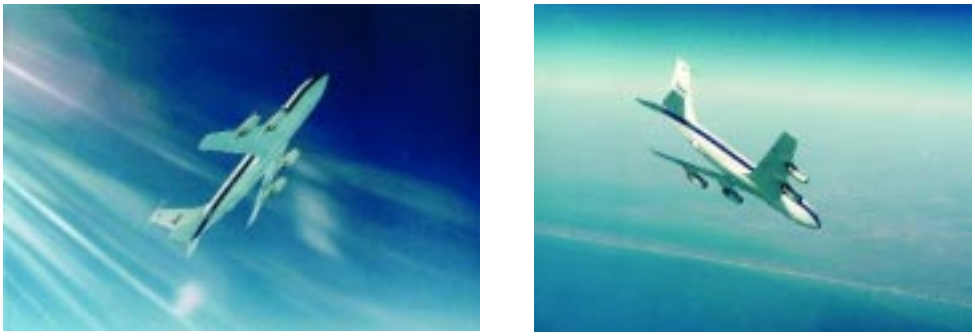


Figure 42: A typical flight mission on a KC-135 lasts about two to three hours. During each steep dive, the passengers experience 20 to 25 seconds of reduced gravity.

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.

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.

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

SPINOFF SPOTLIGHT

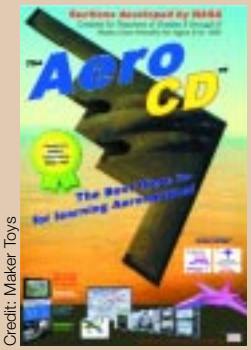
Students soaring high with software spinoff

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

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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.

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.

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.

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.

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.

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
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.

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.

As Only NASA Can: Exploration Capabilities

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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

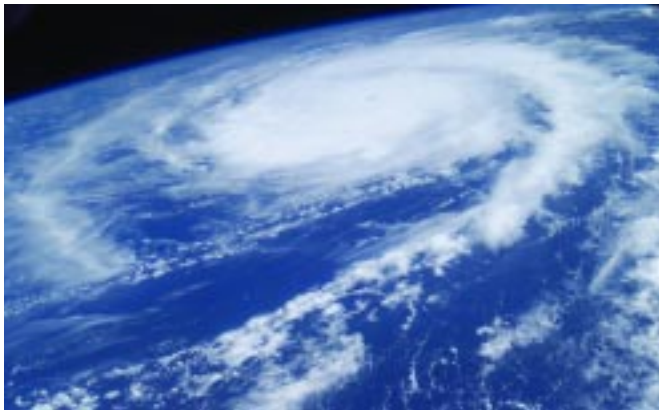

Figure 53: Astronaut Mike Fincke took this photo of Hurricane Frances while aboard the ISS as he flew 230 miles above the storm on, Aug. 27, 2004. At the time, Frances was about 820 miles east of the Lesser Antilles in the Atlantic Ocean.

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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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.

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).

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.